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FOSSIL ENERGY

ENVIRONMENTAL ANALYSIS

1978 C-b Annual Report, Volume 2

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Occidental Oil Shale, Inc.
Grand Junction, Colorado

U. S. DEPARTMENT OF ENERGY

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1978 C-b ANNUAL REPORT

VOLUME 2

ENVIRONMENTAL ANALYSIS

April 20, 1979

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C·b Shale Oil Project
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FOREWORD

The 1978 C-b ANNUAL REPORT is submitted to fulfill the requirements of the Oil Shale Lease as stated in Section 16(b) of the Lease, Section 1.(C)(4) of the Lease Environmental Stipulations, and Condition of Approval (No. 3) of the Detailed Development Plan. This report consists of the following volumes:

Volume 1 - Summary of Development Activities, Costs and Environmental Monitoring
Volume 2 - Environmental Analysis
Appendix 2A - Volume 2 Supporting Data
Appendix 2B - Volume 2 Time Series Plots

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1978 C-b Annual Report, Volume 2

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1.0 INTRODUCTION AND SUMMARY

1.1 Scope

The Environmental Baseline Period for Oil Shale Tract C-b covered the period from November 1, 1974, to October 31, 1976. Results have been reported in nine Quarterly Data Reports, eight Quarterly Summary Reports, Annual Summary and Trends Report (1976), and a 5-volume Environmental Baseline Program, Final Report (1977), all submitted to the Area Oil Shale Supervisor.

From November 1, 1976 through August 31, 1977, the C-b Tract was under a period of suspension of the Federal Oil Shale Lease. This period was known as the Interim Monitoring Phase. Environmental data for this time period were submitted to the Area Oil Shale Office (AOSO) on October 14, 1977 (Interim Monitoring Report #1). The Interim Monitoring Period was later extended by the AOSO to cover the period from September 1, 1977 through March 31, 1978. Data for this time period were submitted to the AOSO on May 15, 1978 (Interim Monitoring Report #2). The Development Monitoring Program was initiated in April 1978. Final approval of the Development Monitoring Plan by the AOSO is expected in the near future. Data for the time period from April 1978 through September 1978 were submitted on January 15, 1979 to the AOSO. Subsequent semi-annual data reports are scheduled for delivery every January 15 and July 15.

This is the first environmental analysis of data for Oil Shale Tract C-b since the final report of the Environmental Baseline Program was published in 1977.

This report, 1978 C-b Annual Report, Volume 2, Environmental Analysis, presents analyses in all of the broad environmental areas identified in the Development Monitoring Program for data collected since November 1976. Because there is always a data-lag and reduction problem, analyses for some studies are based on data only through September 1978. This report is not as detailed or comprehensive as the 5-volume Environmental Baseline Program, Final Report (1977). It need not be. The Interim Monitoring and Development Monitoring Programs have been reduced and changed from the Environmental Baseline Monitoring Program in many areas. Therefore, emphasis is now placed on key indicators of environmental quality and/or change which are evaluated in this report.

The report outline follows closely the outline of the Development Monitoring Program document for ease of cross reference.

1.2 Purpose

The purpose of this report is to fulfill the requirement of the lease to provide the Area Oil Shale Supervisor's Office with an annual report of environmental analyses. The Development Monitoring Plan states the following objectives with respect to environmental monitoring:

> The purposes or objectives of environmental monitoring as defined in Section 1 (C) of the Stipulations are to provide: 1) a record of changes from conditions existing prior to development operations,

as established by the collection of baseline data; 2) a continuing check on compliance with the provisions of the Lease and Stipulations, and all applicable Federal, State and local environmental-protection and pollution control requirements; 3) timely notice of detrimental effects and conditions requiring correction; and 4) factual basis for revision or amendment of the Stipulations.

This report documents the analyses and conclusions relative to assessment of potential environmental impacts and trends that may be indicated in the collected data. Since development activities were not started until 1978, much of the data and analyses may be considered as a continuation of environmental baseline and background definition.

1.3 Summary

Environmental monitoring and analyses are continuing on Oil Shale Tract C-b. Development activities commenced within the past year have resulted in increased activity on the Tract in the form of off-road vehicular use, facility construction, shaft sinking, and traffic into and out of the area. All activity has been conducted within strict adherence to environmental, permit, and lease regulations. Environmental impacts, where they exist, have been confined to the immediate area and within limits defined in the Detailed Development Plan.

The following paragraphs present brief highlights of the report sections. A foldout map showing all of the C-b Tract Development Monitoring sites is provided in a jacket in the back of this report.

1.3.1 Tract Photography

A tract surface and aerial photography program has been initiated to provide permanent records of change and surface disturbance. Sufficient time lapse has not occurred to identify other than purely qualitative effects of wet or dry years on vegetation from the aerial photographs.

1.3.2 Indicator Variables

The Development Monitoring Program has been brought into sharper focus with the identification of Class 1 indicator variables. These are key environmental variables collected at representative stations in at least a monthly sampling frequency. Time series plots, largely generated by the computer from the data base, are presented in Appendix B. These plots will be maintained and updated monthly (as a goal) to provide visual analyses of trends and interrelationships.

1.3.3 Hydrology

Regarding hydrology, analyses of USGS Gauging Stations surface water quality and quantity data reveal no adverse trends for indicator variables either over time or between station locations. Streamflow records on

Piceance Creek above and below the C-b Tract show no change in mean annual flows. One-day minimum flow averages may be less than one cubic foot per second (cfs). Maximum peak flows recorded since baseline were 520 cfs on July 19, 1977 upstream from the C-b Tract, and 492 cfs on September 3, 1977 downstream from the Tract.

A few isolated statistical trends in water quality parameters (sulfate, pH, and arsenic) were noted for some water quality data obtained from springs and seeps. However, suspected spurious values as well as paucity of data discount the significance of these at this time. Any trends at this point in time of very limited development activity would be an indication of a trend in the baseline data.

Water quality and level data for selected alluvial wells and indicator variables showed no overall trends with time from baseline. Comparison of parameter mean values between stations showed no significant differences for most comparisons. The notable exception is for specific conductance which showed differences in four of six comparisons. Water level in bedrock wells showed no trends over time.

1.3.4 Aquatic Ecology

It is useful to relate the previous hydrologic discussion to qualitative aquatic ecological considerations as they pertain to Piceance Creek. Piceance Creek as an ecosystem has been characterized as a "productive, disrupted system existing under marginal physical and chemical conditions," imparting the impression of "marginal, low quality aquatic environment" (Woodling and Kendall (1974)).

Biological production in Piceance Creek is presently restricted by a combination of natural and man-caused factors. Natural factors limiting biological production are the unstable nature of most of the streambed and irregular discharge. Loose sand, silt and mud comprise much of the substratum. These materials are easily shifted about by currents, particularly those associated with runoff of snowmelt and high intensity thunderstorms. In times of low flow, much of the streambed becomes dewatered, thus exposing biota to possible desiccation.

Land use practices along Piceance Creek intensify the adverse effects of some natural limiting factors. Cattle grazing has probably reduced the vegetative cover of the watershed and thereby contributed to the irregularities in stream flow. Cattle trample stream banks and willow growth along the streams and thus destroy cover for fishes. Irrigation diversions dewater sections of Piceance Creek so that they may be intermittently dry, and return water probably leaches salts from the fields and increases the load of dissolved solids. Ammonia and nitrogen may be leaching in significant amounts from manure emanating from winter feeding concentration of cattle along Piceance Creek.

The water of Piceance Creek is high in dissolved salts relative to the "average" North American stream; however, the load in Piceance Creek is not unusually great for streams in semi-arid western localities. Low quality-high salinity groundwater from deep aquifers reaches Piceance Creek via springs discharging into it, especially in reaches downstream from Ryan Gulch. Although the salinity of lower Piceance Creek is greater than in upstream reaches, there is no unambiguous evidence that salinity is limiting total biological production.

1.3.5 Air Quality

With regard to air quality, gaseous constituents measured include sulfur dioxide, hydrogen sulfide, carbon monoxide, ozone, and oxides of nitrogen; total suspended particulates have also been measured. For the overwhelming majority of the time, SO_2, H_2S, and CO have indicated background levels below the lower level of significance of the instruments. Only for ozone and total suspended particulates have significant values been measured. Ozone-concentration shifts to high values show correlation with weather-related meteorological parameters. High particulate concentrations to date are judged to be due solely to fugitive dust. Time series plots do not identify any discernible trends in either gaseous constituents or particulates over time, except for some seasonal variations in particulates. Particulate concentrations are usually highest in spring and fall with minimums in winter. No specific dependence of concentrations on wind speed or direction has been noted.

Mean annual visual range in 1978 was 130 km (81 miles), with a seasonal Spring minimum of 126 km (78 miles) and Fall maximum of 138 km (86 miles). No significant change in the annual mean has been noted since the 1975-1976 measurements.

1.3.6 Meteorology

Climatological records indicate an annual mean temperature of 6-7° C over the past four years. Time series analyses of monthly means has demonstrated no trend in long-term mean values. Cold air drainage results in winter minima in Piceance Valley near -43° C. Although 1977 was the wettest of the four years (35.7 cm), its distribution was such that it came too late in the year to be a major influence on productivity. Lightest annual precipitation was 23.6 cm in 1976. Peak storm intensities reached 4.3 cm precipitation on September 3, 1977.

Predominate winds on Tract continue to be from the south-southwest with Spring and Summer showing higher wind speeds (5-8 m/sec) than Fall and Winter (1-3 m/sec) at the 10-meter level above surface. Winds from the Tract direction generally become channeled by Piceance Valley walls toward the WNW downstream direction of Piceance Creek during late afternoon and night; directions reverse in daytime. Air is typically stable during night and early morning and unstable in late morning and afternoon.

1.3.7 Noise

The environmental noise program deals with both traffic and tract-generated noise levels. The discrete (weekly) traffic noise level measurements indicated noise levels approximately nine dbA above baseline peaks. Continuous noise measurements (every sixth day) indicate no significant increases due to the tract activities in average noise levels for two 12-hour periods (7 p.m.-7 a.m. and 7 a.m.-7 p.m.).

1.3.8 Wildlife Biology

Maximum weekly counts of deer observed along Piceance Creek since baseline have always occurred in spring and have varied from 1,512 in 1976 to 1,034 in 1978 with 1975 and 1977 values intermediate to these. Road kills in any week usually vary from less than 1% to 1.5% of those counted in any given week. A total of 125 deer were killed along the road from September 1977 to May 1978. Use of company buses has been the principal mitigative measure in reducing traffic on Piceance Creek road. Regarding natural deer mortality in lateral draws and gulches, fawns have comprised 80% of deer mortality each year. Age class composition for mule deer wintering near the tract are as follows: 79 fawns per 100 does, 26 bucks per 100 does, and 64 fawns per 100 adults.

Regarding medium-sized mammals, fewer coyotes and more cottontail rabbits were noted in 1978 than in 1977.

As with previous sampling periods, greater avian songbird diversity has been noted in pinyon-juniper woodlands as opposed to chained pinyon-juniper; similarly more mourning doves were found in the unchained habitats. Nesting raptors in the tract vicinity in 1978 consisted of red-tailed hawks and great-horned owls. Although bald eagles have been observed in the tract vicinity, none nested or remained in the area; they were merely flying through. No threatened or endangered species were found on or near the Tract.

1.3.9 Vegetation

Monitoring data suggest that over the past four years there have been no major changes in species composition or community structure in the chained rangelands. The general trend has been for a slight increase in total cover and also for an increase in the density of big sagebrush. These changes are closely related to the successional characteristic of the chained rangelands. The trend for increasing shrub cover and density is likely to continue until the tree saplings mature into tree-size individuals.

The production patterns within the vegetation types observed during the Development Monitoring period are the same as those observed during the baseline period. Utilization continues to be seasonal and by mid-growing season is nearly non-detectable because of livestock use patterns. Observed differences in productivity between intensive study plots appear to be more related to site differences than to any development-related activities. Herbaceous production is closely related to precipitation; significant differences in production between years are related to differences and fluctuating patterns of precipitation in this semi-arid region. Fertilization of upland chained areas appears to result in an increase in herbaceous production. Because of a limited sample size and high data variability, the differences between fertilized areas and control areas were not significant. Shrub production and utilization (bitterbrush and mountain mahogany) for this past year differed markedly from those of 1976-1977 in that production was lower and utilization by mule deer was much higher. Precipitation distribution was more favorable to productivity in 1978 than in 1977.

Revegetation monitoring will be conducted on sites which have undergone surface disturbance and on future raw-shale disposal sites. Erosion control and rehabilitation are discussed in Volume 1, including the reclamation activity-schedule defining affected areas, disturbance timetable, reclamation time span, and disturbed acreage.

1.3.10 Ecosystem Interrelationships

Ecosystem interrelationship studies have been initiated as a means of assessing the potential impact of environmental perturbations resulting from development activity. Quantitative studies to date included: (1) effects of climatic variations on herbaceous productivity; (2) effects of traffic, climate, and size of mule-deer herd on deer road-kill; and (3) effects of urbanization on watershed hydrologic response time. Principal results established were as follows: (1) herbaceous productivity correlated best with precipitation in April-May-June and total precipitation of the previous year; (2) deer road-kill correlated best with deer road count; (3) a lag time of 5.5 hours was demonstrated to exist currently between a precipitation event and peak flow on Piceance Creek below the tract; future analyses will determine potential effects of urbanization on this lag or response time.

1.3.11 Items of Prehistoric and Historic Interest

Recent developments regarding items of prehistoric or historic interest have been primarily associated with a planned route for a powerline from Meeker to the Tract. One prehistoric site and five isolated "finds" were located near the proposed right-of-way; mitigation will be accomplished by avoiding these sites through minor rerouting.

1.3.12 Health and Safety

With regard to health and safety, accident frequency analyses and inspection reports (Mine Safety and Health Administration (MSHA) and Colorado Division of Mines (CDM)) are included in the Development Monitoring Plan and its reports. At C-b based on 442,218 man-hours worked during 1978, there were three lost-time accidents totaling seven lost-time days. The site injury incidence rate was 1.35 (incidents per 200,000 man-hours), and the severity measure was 3.16. These compare favorably with the national averages for underground mines of 16.32 and 23.0 respectively.

2.0 TRACT DEVELOPMENT SCHEDULE AND MAPS

2.1 Development Schedule

The proposed development schedule is presented as Figure 3-1 of Volume 1 of this report. A comparison of proposed vs. actual schedules for calendar 1978 is presented as Figure 3-2 of Volume 1.

2.2 Maps

A fold-out map depicting monitoring site locations for Development Monitoring is included in the jacket inside the back cover of this report. Four-digit computer codes are also shown on the map; comparisons of computer codes and "conventional" site locations are included in Appendix A2.2.

Related maps are included in each chapter as appropriate.

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3.0 TRACT PHOTOGRAPHY

3.1 Scope and Rationale

Section 1 (C) of the Environmental Lease Stipulations requires that the Lessee conduct monitoring programs to measure perceptible changes from baseline conditions. Toward this end both a surface and an aerial photography program have existed since baseline. For the surface program, color photos are obtained annually. For the aerial program, black and white and color/infrared are obtained annually and color once every five years.

3.2 Surface Program

3.2.1 Objectives

The objectives of the surface program are to provide:
1) a record of changes from conditions existing prior to development operations;
2) visual evidence of successional changes in the ecosystem;
3) a visual record of surface disturbance;
4) an historic account of surface development; and
5) a visual basis for revision or amendment of the Stipulations.

3.2.2 Experimental Design

Thirty-one points have been selected for Development Monitoring from which a 360° pan is photographed on a yearly basis. (Figure 3.2.2-1). A 35mm camera with an f 1.8, 55mm lens using Ektachrome Professional Type R, ASA 200 film is used. Once each year in June between 10:00 a.m. and 2:00 p.m. on cloudless days, a 360° photo pan is taken from each of the thirty-one photo map stations.

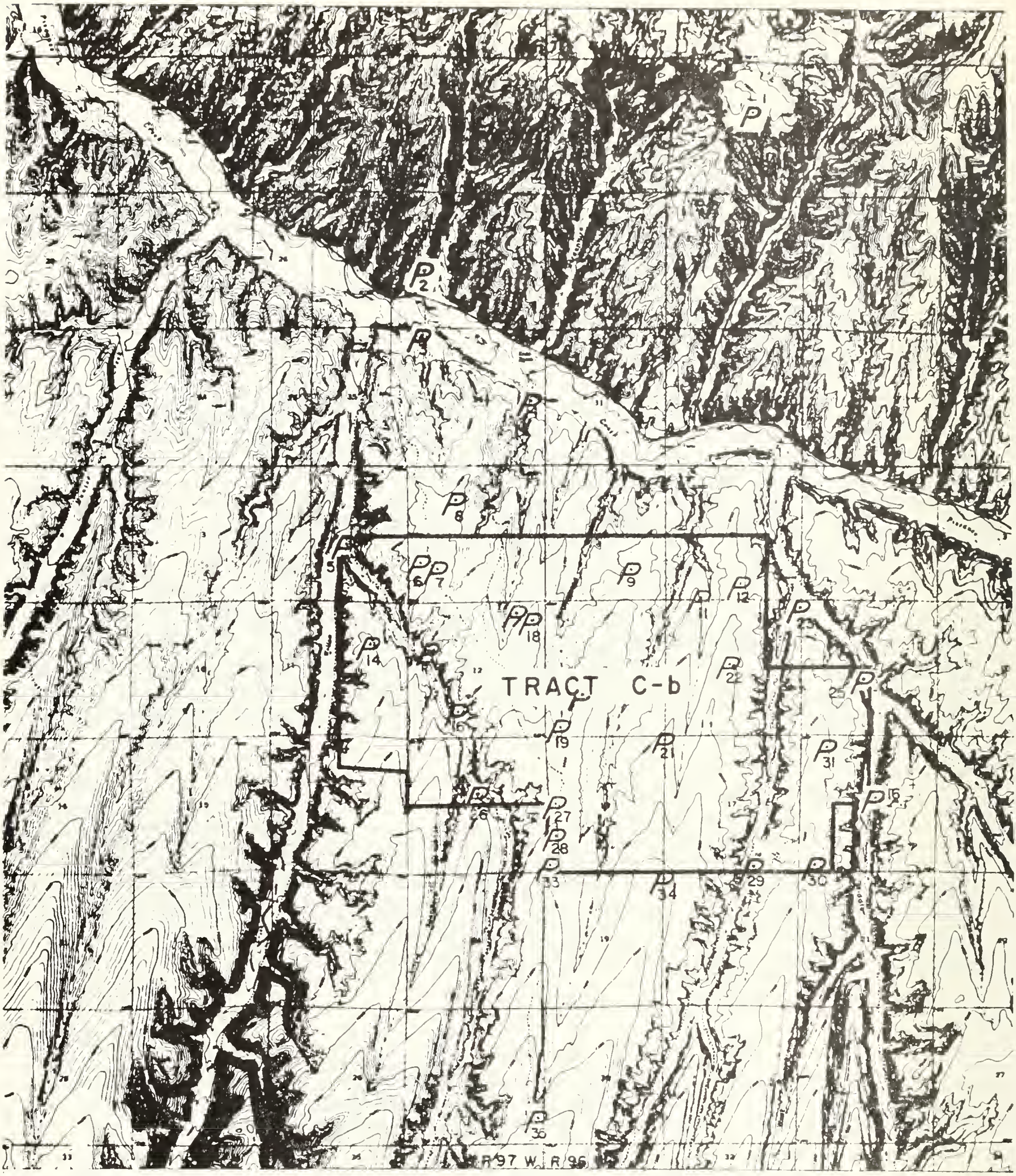
3.2.3 Archiving Methods

A complete set of the 35mm slides are numbered as to station, aspect and date. This set is stored in plastic envelopes and bound in a 3-ring binder, then filed in a unit designed to curtail dust and light as a part of the permanent record of the C-b Shale Oil Project. For Development Monitoring this record includes weather condition, camera and film data, height of camera above ground and direct or diffuse lighting identification.

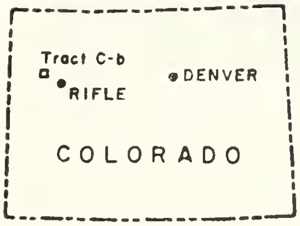
3.2.4 Results and Conclusions

Photographic coverage of the C-b Tract in 1977 and 1978 consisted of from five to fifteen slides of thirty-five selected points on and around the Tract. The camera was set up over each point and oriented so the center of the first slide was true North. With each succeeding slide the camera was rotated twenty-five degrees clockwise.

The film chosen for both 1977 and 1978 was Kodak Ektachrome Professional with an ASA of 200. The high ASA number was chosen because it allows more detail



SURFACE PHOTOGRAPHY NETWORK



INDEX MAP

^{6}P = Photo Map Station

Figure 3.2.2-1

to be visible in shaded areas and reduces the "blocking up" that occurs with a slower film. Since this film has a very high sensitivity to blues, an 81A filter was utilized to cut the blue cast and a polarizing filter was placed over this to give better haze penetration. The film was slightly under-exposed to give a more dense slide with an increased dye concentration; this technique extends the life of the slide when properly stored.

During 1977, photo points 4, 10, 13, 14 and 26 were not recorded due to snowfall (9 November - 16 November) or mechanical failure. During 1978, photo points 2, 4, and 13 were not recorded due to mechanical failure.

Sufficient time lapse has not occurred to identify other than a wet or dry year.

3.3 Aerial Program

3.3.1 Objectives

The objectives of aerial photographic coverage of the C-b Tract and a one-mile buffer utilizing vertical viewing are to provide:

1) a record of changes from conditions existing prior to development operations, as established by the collection of baseline data;
2) timely notice of certain detrimental effects and conditions requiring correction;
3) general vegetative conditions (correlated with Biology);
4) inventory of site physical conditions; and
5) subsidence details.

3.3.2 Experimental Design

For Development Monitoring, the scale is 1:6000. Film is black and white, color and color/infrared. Resolution is such that an object three feet across on the horizontal plane can be seen with the unaided eye. Flight lines are flown from West to East and photography taken from 10:00 a.m. to 2:00 p.m. on cloudless days. Side overlap of 40-50% and fore-and-aft overlap of 60% between photographs are to be specified. Aerial photographs will show visible ground control points as 3' x 12' white crosses on established section corners within the C-b Tract.

Vertical aerial photography is obtained on or about the 15th of June. Frequency is annually for black and white and color/infrared and once every five years for color.

3.3.3 Methods

Regarding archiving, one set of color prints is used for construction of a mosaic; and one set of black and white, color, and color/infrared is stored in a unit designed to curtail dust and light as a part of the permanent record of the C-b Shale Oil Venture. The annual record during Development Monitoring includes weather conditions, camera and film data, height of camera above ground and information on direct or diffuse lighting identification.

An uncontrolled color mosaic for the June 1974 flight is on display at Occidental's Grand Junction offices. The next color mosaic will be compared with June 1974 mosaic to identify major areas of change and a map indicating changes prepared.

Stereo pairs will be utilized to examine the most significant major changes in more detail. These results will be documented in future analysis reports.

3.3.4 Results and Conclusions

The results of the 1977 color aerial photography were such that an uncontrolled mosaic could not be assembled due to severe drift in flight lines. Prints have been archived in accordance with the above described archiving techniques. Vertical aerial photography was not obtained by C-b in 1978. Previous arrangements were made with the EPA to supply the C-b Shale Oil Project with aerial photography. A 1:34000 print was supplied in early 1979 as overflown in September 1978. This print will be archived in accordance with the Development Monitoring Program.

4.0 INDICATOR VARIABLES

Indicator variables are selected monitored environmental parameters that can be expected to provide the earliest clues of potential change in the baseline environment. This section identifies the indicator variables selected for environmental disciplines of hydrology, air quality and meteorology, noise, and biology that will be observed most closely.

4.1 Role in Impact Assessment

Efficient monitoring of environmental quality requires close observation of a few key variables. This includes those variables that are: 1) most sensitive to change in quality; 2) indicators of natural or climatic change; and 3) subject to Federal and State standards because of concern for human health and public welfare. For these reasons the Development Monitoring Plan has identified and emphasized in the collection plan key indicator variables in each of the environmental disciplines.

Close observation of the identified key indicator variables requires early data reduction and analysis in order to flag changes or adverse time-trends in the observations. Visibility is provided by maintaining current time-series plots of the key variables. Impact of development activity is also assessed through statistical comparison of data collected near development and control sites. If trends and differences signal the probable occurrence of adverse environmental impact, additional and increased monitoring will be triggered. (Referred to as Systems Dependent Monitoring.) At present, no Systems Dependent Monitoring has been "triggered."

4.2 Identification of Class 1 Indicator Variables

Indicator variables have been identified in the Development Monitoring Plan as a subset of the monitored environmental parameters. However, the combinations of indicator variables with the number of collection stations exceed 1000. Therefore, Class 1 Indicator Variables have been identified in order to further reduce the number of parameter-site combinations to a realistic quantity (171) for the purpose of close observation. Class 1 Indicator Variables are key environmental variables collected at representative stations on at least monthly frequency. Time series plots will be maintained and updated monthly for these Class 1 Indicator Variables.

This section identifies only the Class 1 Indicator Variables. However, all monitored variables are included in the data reports and the following chapters of this Annual Report.

4.2.1 Tract Photography

Tract photography is to be carried out annually under a surface program and an aerial program as defined in the Development Monitoring Program. While the photographs provide permanent records of existing conditions, no photo interpretations have been made at this time.

Therefore, no Class 1 Indicator Variables associated with tract photography are identified.

4.2.2 Hydrology

Class 1 Indicator Variables for hydrology are identified in Table 4.2.2-1. The number of collection sites has been screened to four major USGS Gauging Stations, four springs and seeps, and four alluvial wells for this group. Parameters are collected either daily or monthly as indicated by the codes in the table. For cross-referencing ease, Table 4.2.2-2 presents the table numbers in Appendix B where these time-series data are presented under separate volume.

4.2.3 Air Quality and Meteorology

Class 1 Indicator Variables and stations for air quality and meteorology are identified in Table 4.2.3-1. Collection frequency for those parameters coded with D is continuous; hourly averages are reported in the data reports. Daily averages and peaks calculated from the hourly averages are used in the time-series plots for these variables. Daily totals will be plotted for those coded with T. Table 4.2.3-2 cross-references the time-series plots.

4.2.4 Noise

Noise is measured at two stations as decibel level. Class 1 Indicator Variables are peak measurements of background noise level for daytime (0700 through 1900 hours) and for nighttime (1900 through 0700 hours). These are shown in Tables 4.2.4-1 and 4.2.4-2.

4.2.5 Biology

Much of the biology data collection and analysis are on a seasonal or annual time frequency. These data and analyses are important indicators for possible oil shale development environmental impact. However, under the definition of Class 1 Indicator Variables as those with at least monthly collection, a much smaller set of biological environmental parameters are identified. These are shown in Tables 4.2.5-1 and 4.2.5-2. Microclimate data are collected twice monthly indicated by 2M in the first table. Monthly and weekly observation frequency are shown with M and W respectively in the tables.

TABLE 4.2.2-1

HYDROLOGY CLASS 1 INDICATOR VARIABLES

VARIABLE	MAJOR U.S.G.S. WU07	WU61	WU58	WU22	SPRINGS AND SEEPS WS01	WS03	WS06	WS07	ALLUVIAL WELLS WA03	WA05	WA06	WA08
1. Ammonia	M	M	M	M								
2. Boron	M	M	M	M								
3. Fluoride	M	M	M	M								
4. Total Dissolved Solids	M	M	M	M								
5. Arsenic	M	M	M	M								
6. Sediment	M	M	M	M								
7. Precipitation	M	M	M	M								
8. pH	D	D	D	D	M	M	M	M	M	M	M	M
9. Temperature	D	D	D	D	M	M	M	M	M	M	M	M
10. Flow	D	D	D	D								
11. Conductivity	D	D	D	D	M	M	M	M	M	M	M	M
12. Dissolved Oxygen	D	D	D	D	M	M	M	M				
13. Level									M	M	M	M

NOTES: Frequency of data sampling is coded: D for daily average of continuous sampling; M for monthly samples.

TABLE 4.2.2-2

HYDROLOGY CLASS 1 INDICATOR VARIABLE TIME-SERIES INDEX

	MAJOR U.S.G.S.				SPRINGS AND SEEPS				ALLUVIAL WELLS			
VARIABLE	WU07	WU61	WU58	WU22	WS01	WS03	WS06	WS07	WA03	WA05	WA06	WA08
1. Ammonia	B5.2.1-1	-2	-3	-4								
2. Boron	-5	-6	-7	-8								
3. Fluoride	-9	-10	-11	-12								
4. Total Dissolved Solids	-13	-14	-15	-16								
5. Arsenic	-17	-18	-19	-20								
6. Sediment	-21*	-22*	-23*	-24*								
7. Precipitation	-25*	-26*	-27	-28								
8. pH	-29	-30	-31	-32	B5.2.2-1*	-2*	-3*	-4*	B5.3.1-1*	-2*	-3*	-4*
9. Temperature	-33	-34	-35	-36	-5*	-6*	-7*	-8*	-5*	-6*	-7*	-8*
10. Flow	-37	-38	-39	-40								
11. Conductivity	-41	-42	-43	-44	-9*	-10*	-11*	-12*	-9*	-10*	-11*	-12*
12. Dissolved Oxygen	-45	-46	-47	-48	-13*	-14*	-15*	-16*				
13. Level									-13	-14	-15	-16

NOTES: * Plots not included (Insufficient Data)

TABLE 4.2.3-1

AIR QUALITY AND METEOROLOGY CLASS 1 INDICATOR VARIABLES

VARIABLE	SAMPLING STATIONS						
	AB20	AA23	AB23	AC20	AD42	AD56	AREA
1. SO_2	D		D				
2. H_2S	D		D				
3. O_3	D		D				
4. NO_x	D		D				
5. NO_2	D		D				
6. CO	D		D				
7. Particulates (every 3rd day)	T		T		T	T	
8. WS - 10m	D	D			D	D	
9. WD - 10m	D	D			D	D	
10. WS - 30m		D					
11. WD - 30m		D					
12. RH			D				
13. TEMP - 10m	D		D		D	D	
14. PRESS			D				
15. SOLAR			T				
16. ΔTEMP - (60m-10m)		D					
17. PRECIPITATION	T		T				
18. EVAPORATION			T				
19. INV HT				D			
20. MIX HT				D			
21. VISUAL RANGE (every 6th day)							VR

NOTES: Frequency of sampling is continuous for all variables except visual range. Daily averages with min and max hourly values are plotted for those variables coded with D. Daily totals are plotted for those coded with T.

TABLE 4.2.3-2

AIR QUALITY AND METEOROLOGY CLASS 1 INDICATOR VARIABLE TIME-SERIES INDEX

VARIABLE	SAMPLING STATIONS						
	AB20	AA23	AB23	AC20	AD42	AD56	AREA
1. SO_2	B6.2.1-1		-2				
2. H_2S	-3		-4				
3. O_3	-5		-6				
4. NO_x	-7		-8				
5. NO_2	-9		-10				
6. CO	-11		-12				
7. Particulates (every 3rd day)	B6.2.2-1		-2		-3	-4	
8. WS - 10m	B6.3.2-1	-2			-3	-4	
9. WD - 10m	-5	-6			-7	-8	
10. WS - 30m		-9					
11. WD - 30m		-10					
12. RH			B6.3.1-1				
13. TEMP - 10m	-2		-3		-4	-5	
14. PRESS			-6				
15. SOLAR			-7				
16. ΔTEMP - (60m-10m)		-8					
17. PRECIPITATION	-9		-10				
18. EVAPORATION			-11				
19. INV HT				B6.3.2-11			
20. MIX HT				-12			
21. VISUAL RANGE (every 6th day)							B6.2.3-1*

* Plots not included (Insufficient Data)

TABLE 4.2.4-1

NOISE CLASS 1 INDICATOR VARIABLES

VARIABLE	SAMPLING STATIONS	
	NA09	NB19
1. Daytime Noise (0700-1900)	P	P
2. Nighttime Noise (1900-0700)	P	P

NOTES: Sampling Frequency is continuous with peak db for the time interval coded with P.

TABLE 4.2.4-2

NOISE CLASS 1 INDICATOR VARIABLE TIME-SERIES INDEX

VARIABLE		SAMPLING STATIONS	
		NA09	NB15
1. Daytime Noise (0700-1900) 2. Nighttime Noise (1900-0700)	COMBINED	B7.2.1-1*	B7.2.2-1

* Plots not included (Insufficient Data)

TABLE 4.2.5-1

BIOLOGY CLASS 1 INDICATOR VARIABLES

VARIABLE	MICROCLIMATE STATIONS										U.S.G.S.		PICE-ANCE CREEK ROAD	TRAFFIC		
	BC01	BC02	BC03	BC04	BC05	BC06	BC07	BC08	BC09	BC13	WU07	WU61		CB	PCN	PCE
1. PRECIPITATION	2M	2M	2M	2M	2M	2M	2M	2M	2M	2M						
2. SNOW DEPTH	2M	2M	2M	2M	2M	2M	2M	2M	2M	2M						
3. TEMP MAX	2M	2M	2M	2M	2M	2M	2M	2M	2M	2M						
4. TEMP MIN	2M	2M	2M	2M	2M	2M	2M	2M	2M	2M						
5. PERIPHYTON BIOPRODUCTIVITY											M	M				
6. DEER ROAD COUNT													W			
7. DEER ROAD KILLS													W			
8. TRAFFIC COUNT														W	W	W

NOTES: Microclimate data are collected twice monthly (2M);
Periphyton bioproductivity collected monthly (M);
and Deer and Traffic are counted weekly (W).
CB - Traffic Count between Piceance Creek Road and C-b Tract.
PCN - Piceance Creek Road north of C-b turnoff.
PCE - Piceance Creek Road east of C-b turnoff.

TABLE 4.2.5-2

BIOLOGY CLASS 1 INDICATOR VARIABLE TIME-SERIES INDEX

VARIABLE	MICROCLIMATE STATIONS										U.S.G.S.		PICE-ANCE CREEK ROAD	TRAFFIC		
	BC01	BC02	BC03	BC04	BC05	BC06	BC07	BC08	BC09	BC13	WU07	WU61		CB	PCN	PCE
1. PRECIPITATION ** 2. SNOW DEPTH	B8.7.5-1	-2	-3	-4	-5	-6	-7	-8	-9	-10						
3. TEMP MAX ** 4. TEMP MIN	-11	-12	-13	-14	-15	-16	-17	-18	-19	-20						
5. PERIPHYTON BIOPRODUCTIVITY											B8.6.2-1*	-2*				
6. DEER ROAD COUNT													B8.2.2-1			
7. DEER ROAD KILLS													B8.2.3-1			
8. TRAFFIC COUNT															B8.2.3-2*	

NOTES: * = Plots not included (Insufficient Data)
** = Combined

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5.0 HYDROLOGY

5.1 Introduction and Scope

A development monitoring program has been implemented to provide water quantity and quality data for the purpose of impact evaluation. Presently, streams, springs, seeps, and alluvial and bedrock aquifers are monitored. The program will be expanded to include monitoring of water associated with shafts, impoundments, and shale piles as development proceeds. Data obtained during baseline and interim-monitoring studies established reference levels for use in comparative studies during development. Bedrock quantity and quality data presented in this report, which were gathered prior to subsurface development, may still be considered as representative of "baseline" conditions.

The present hydrologic monitoring network is conceptually the same as during the baseline period. However, the bedrock aquifer system underlying C-b Tract has been redefined. Observation wells were completed in accordance with the concept that the Tract is underlain by two aquifers separated by the Mahogany Zone. Pump spinner tests conducted after the baseline period indicated that highly stratified aquifers and aquitards more accurately characterize the aquifer system. The more complex aquifer-aquitard system is illustrated in Figure 5.1-1. For purposes of identification, these new subdivisions of the previous upper and lower aquifer system are as follows:

1) UPC_1 - Upper Parachute Creek #1: Approximate limits extend from the base of the Four Senators Zone to the base of the A-Groove;

2) UPC_2 - Upper Parachute Creek #2: Extends from the base of the Four Senators Zone to the base of the A-Groove;

3) LPC_3 - Lower Parachute Creek #3: Extends from 30 feet below the base of the A-Groove to the top of the R-5 Zone;

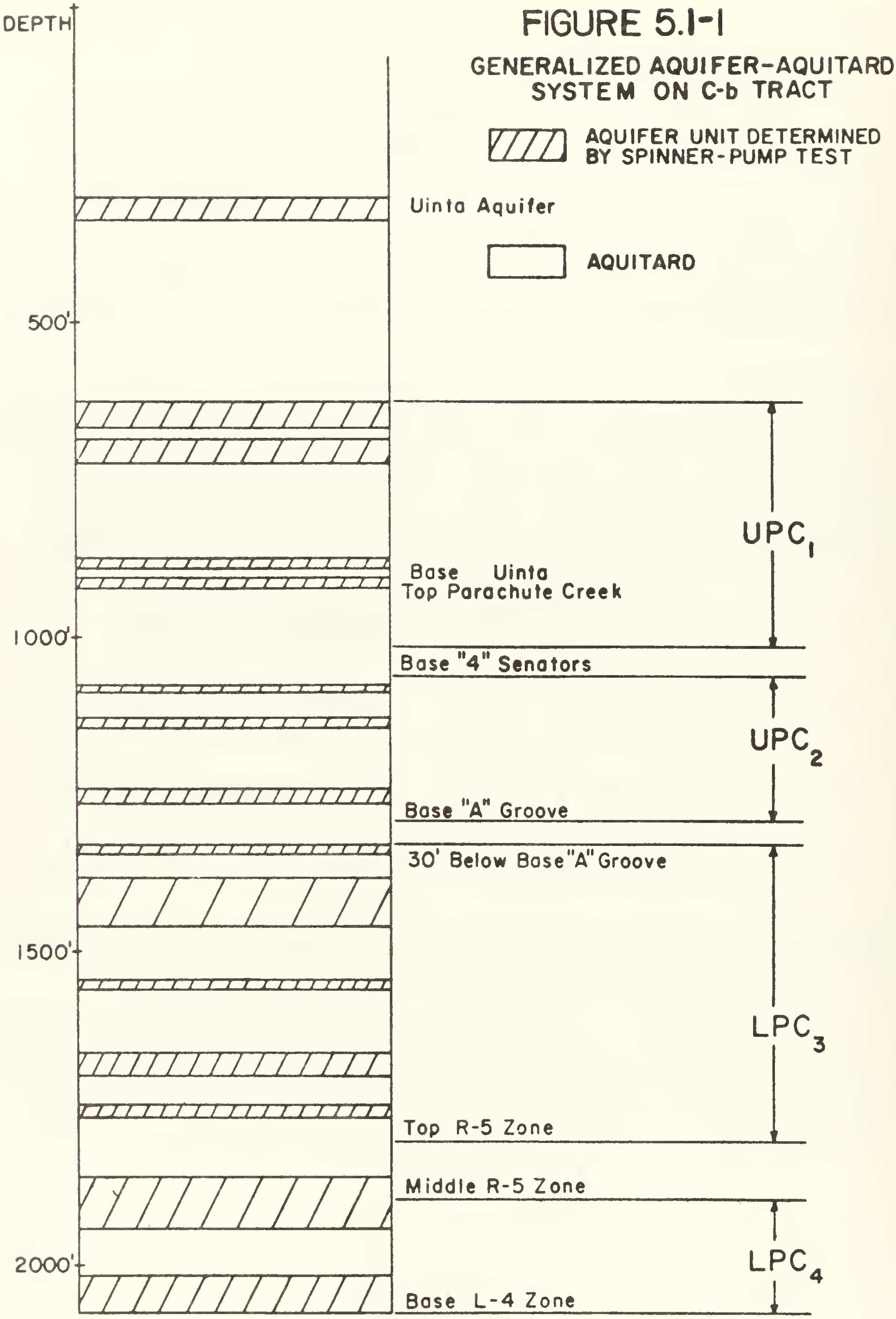
4) LPC_4 - Lower Parachute Creek #4: Extends from the middle of the R-5 Zone to the base of the L-4 Zone.

Bedrock observation wells are scheduled to be recompleted to reflect the new aquifer concept. All water level measurements and water quality data in this report are representative of the present two-aquifer completions.

This section presents the hydrologic analyses performed on the data collected on the C-b Tract to date with emphasis on data collected since November, 1976. An attempt has been made to convert to metric units. However, some of the data and analyses are reported in English units at the request of the Area Oil Shale Supervisor Office Hydrologic Group. Complete conversion to metric units will be made in subsequent Annual Environmental Reports.

FIGURE 5.1-1

GENERALIZED AQUIFER-AQUITARD SYSTEM ON C-b TRACT



5.2 Surface Water Studies

Water quantity and quality data are collected at U.S.G.S. Gauging Stations on Piceance Creek and its tributaries in the C-b Tract vicinity in connection with an ongoing hydrologic monitoring program. The initial two years of the program obtained data relative to baseline conditions. A two-year study, although insufficient to identify trends in stream flow and water quality parameters, provided a preliminary basis for estimating their variability so that changes could be recognized and assessed.

Baseline studies indicated the mean flow for the reach of Piceance Creek adjacent to the Tract to be approximately fifteen cfs. These studies showed the water of Piceance Creek to be hard to very hard with $CaCO_3$ concentrations greater than 300 mg/l. The water was found to be a sodium-calcium-magnesium-bicarbonate-sulfate type.

Data gathered since the end of the baseline period have been used to analyze the mean annual flows, annual peak flows, and annual flow minimums of Piceance Creek. Water quality parameters were analyzed for time series trends and subjected to station-to-station comparisons.

5.2.1 U.S.G.S. Gauging Stations

5.2.1.1 Scope and Rationale

The surface water monitoring program is designed to detect unplanned point discharges, effluents from non-point discharges, and planned discharges from retention ponds. The major emphasis in surface water monitoring will involve non-point source pollution and direct discharges from storage reservoirs. Sources of these types include: (1) increased erosion rates and sediment loads due to construction activities, (2) runoff from process plant and paved areas, (3) runoff carrying solids resulting from air-borne particulate of gaseous emissions, (4) seepage or runoff from shale piles, and (5) infiltration into the groundwater system from reservoirs, ponds, or injection wells, and subsequent discharge at the ground surface.

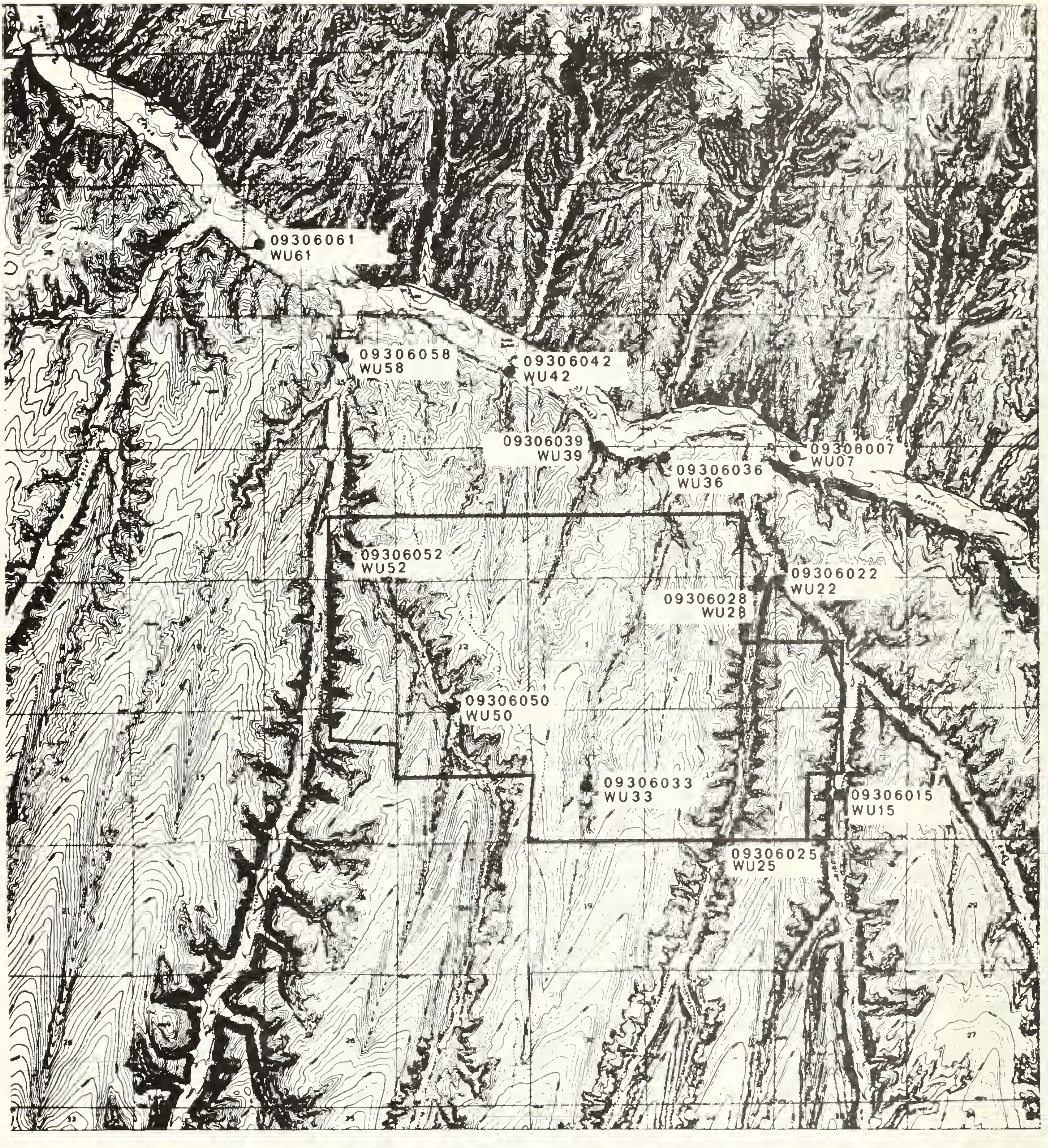
5.2.1.2 Objectives

The monitoring program has been implemented to detect any changes in water quantity or quality that might be attributable to Tract development. Analysis will be undertaken periodically to identify any significant trends or changes between stations relative to discharge and water quality parameters.

5.2.1.3 Experimental Design

Thirteen surface water gauging stations (Figure 5.2.1-1) were constructed on and in the vicinity of C-b Tract by the U. S. Geological Survey in cooperation with the Colorado River Water Conservation District. The gauging stations constitute the surface water monitoring network, which has been in operation since the beginning of the baseline period.

Nine of the stations are located on ephemeral streams. Stations 007, 061, 022, and 058, which are located on perennial drainages and considered major gauging stations, are given as follows:



U.S.G.S. STREAM GAUGING STATION MONITORING NETWORK

FIG. 5.2.1-1

STATION CODE	USGS NUMBER	STATION LOCATION
WU07	09306007	Piceance Creek below Rio Blanco
WU61	09306061	Piceance Creek at Hunter Creek
WU22	09306022	Stewart Gulch
WU58	09306058	Willow Creek

For purposes of analysis, data were drawn from an additional gauging station (not shown in Figure 5.2.1-1) which is approximately five miles downstream of station 061 on Piceance Creek below Ryan Gulch.

5.2.1.4 Results and Discussions

This section is divided into two main sub-sections: stream flow and water quality. Stream flow is further divided into studies of hydrographs, flood frequency analysis and minimal flow analysis. For each of these, methods of analysis and results and discussion are separately identified for clarity.

5.2.1.4.1 Stream Flow: Hydrographs

Methods of Analysis

Plots of daily streamflow are given for Stations WU07 and WU61 in Figures B5.2.1-37 and B5.2.1-38. The hydrographs show the seasonal influence of runoff, evapotranspiration, and irrigation diversions on the flow of Piceance Creek. Flow in Piceance Creek has two components: baseflow and seasonal flow. Baseflow consists of groundwater recharge from alluvial aquifers and perched aquifers in the bedrock. Seasonal flow is comprised of storm runoff and snowmelt. December and January records reflect baseflow conditions while major irrigation diversions occur during the period April through September. The months of February, March, October and November are characterized by variable flows as a function of runoff and off-season irrigation diversions.

Total and mean annual streamflows for Stations WU07 and WU61, as well as Stations WU22 and WU58 are given below (Table 5.2.1-1). Station WU22 monitors the tributary draining Stewart Gulch and Station WU58 gauges the flow of Willow Creek.

TABLE 5.2.1-1 TOTAL AND MEAN ANNUAL STREAM FLOW

Water Year	Sta. WU07		Sta. WU22		Sta. WU58		Sta. WU61	
	Total (ft^3)	Mean (cfs)	Total (ft^3)	Mean (cfs)	Total (ft^3)	Mean (cfs)	Total (ft^3)	Mean (cfs)
1975	4866	13.3	710	2.0	725	2.0	6624	18.1
1976	3653	10.0	674	1.8	865	2.4	6069	16.6
1977	1831	5.0	503	1.4	508	1.4	3604	9.9

Results and Discussion

Discharge totals and mean values recorded for the stations draining the two perennial tributaries of Piceance Creek in the Tract vicinity are strikingly similar. The similarity can be attributed to comparable drainage areas (D_A Willow Creek = 48.7 mi^2; D_A Stewart Gulch = 43.4 mi^2), bedrock, and vegetation. A comparison of mean flows for Station WU07 (upstream) and Station WU61 (downstream) indicates a five cfs gain in discharge between stations. Mean discharge values of the Stewart Gulch and Willow Creek tributaries suggest that 75% of the flow increase between the Piceance Creek stations is due to surface water contributions. Presumably 25% of the gain may be attributed to groundwater inflow.

5.2.1.4.2 Stream Flow: Flood Frequency Analysis

Methods of Analysis

Prediction of the magnitudes of peak discharges for given frequencies at a gauging station or the recurrence intervals of floods of selected magnitudes is facilitated by flood frequency analysis. The analysis entails fitting a probability distribution to a sample of floods gauged at a station.

Piceance Creek is monitored by one gauging station with records of adequate length to perform a flood frequency analysis. U.S.G.S. Station 09306200 on Piceance Creek below Ryan Gulch has been in operation since 1965. Where no flood records exist for a given site or where the brevity of record precludes analysis for station records, other stations in the area provide records which can be regionalized and applied to the prediction of floods. Regional flood frequency curves were derived for two stream gauging stations U.S.G.S. 09306007 and 09306061. Station WU07, on Piceance Creek below Rio Blanco, is upstream of tributaries which drain C-b Tract while Station WU61 is downstream, above the mouth of Hunter Creek.

After a minimum of ten years of record has been obtained for an individual station, flood frequency analysis may be performed and compared to the corresponding regional curve. Results obtained from the regional curve will be of the same order of magnitude as those derived from station data.

A flood frequency curve (Figure 5.2.1-2) was plotted using annual peak discharges for water years 1966-1977. The maximum instantaneous discharge of each year was ranked in order of decreasing discharge and the corresponding recurrence interval was determined. (Table 5.2.1-2.)

The recurrence interval equals $\frac{n+1}{m}$, where n is the number of years of record and m is the rank.

Errors are inherent in flood frequency analysis for single stations due to (1) the brevity of most records, (2) the characteristic variability of floods, and (3) the difficulty of fitting theoretical frequency distributions to the sample record. In Figure 5.2.1-2, confidence bands were determined by multiplying coefficients (Beard, 1962) for the 90% confidence level by the standard deviation of the sample ($\sigma = 92.7$). Products obtained were added or subtracted for various discharges of the curve to produce upper and lower confidence bands.

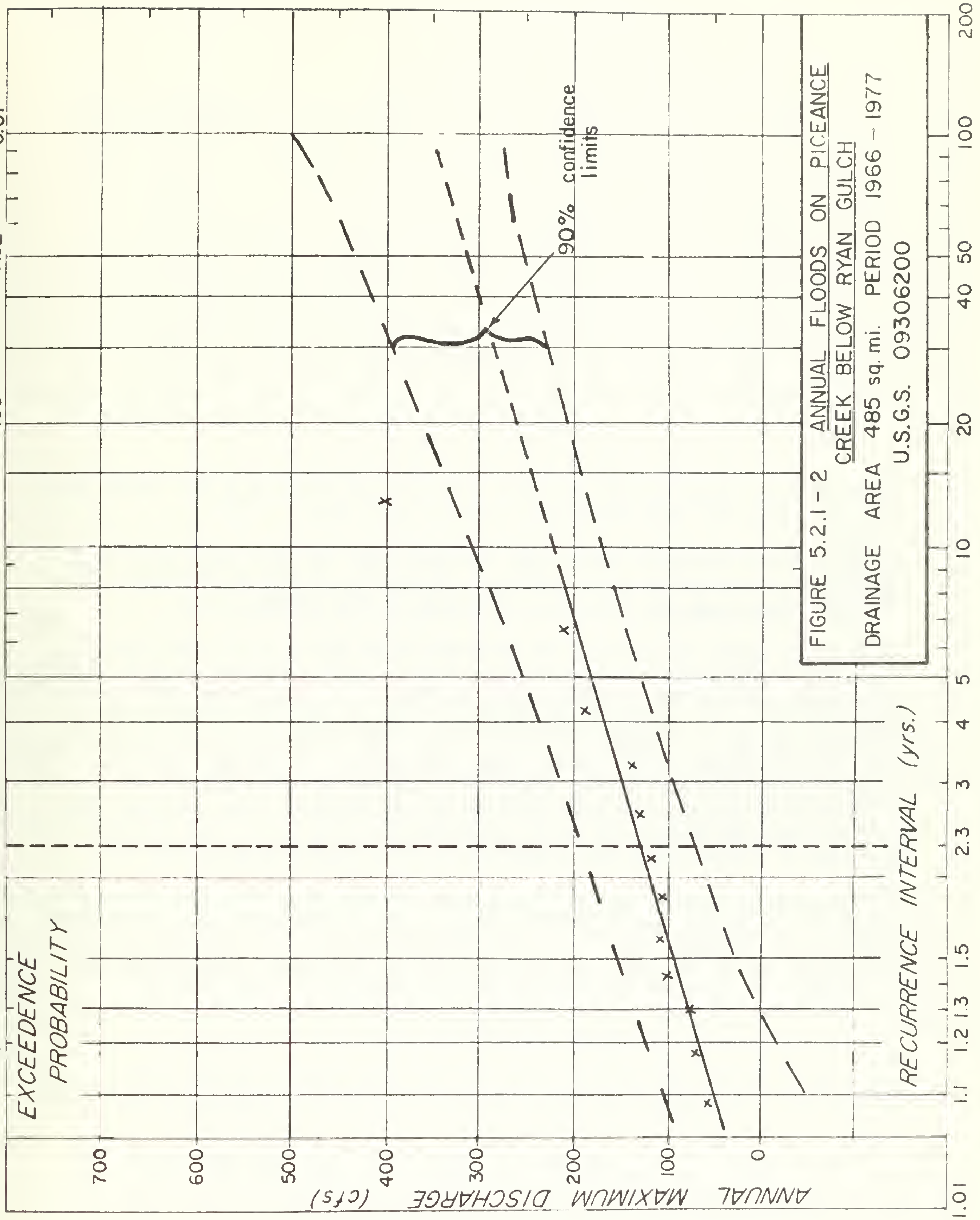


FIGURE 5.2.1 – 2 ANNUAL FLOODS ON PICEANCE CREEK BELOW RYAN GULCH

DRAINAGE AREA 485 sq. mi. PERIOD 1966 – 1977

U.S.G.S. 09306200

TABLE 5.2.1-2

ANNUAL MAXIMUM FLOW RATE

Year	Flowrate (cfs)	Rank Order (m)	Recurrence Interval (years)
1966	400	1	13.00
1971	211	2	6.50
1968	184	3	4.33
1969	141	4	3.25
1977	136	5	2.60
1972	121	6	2.17
1976	107	7	1.86
1970	104	8	1.63
1973	100	9	1.44
1967	75	10	1.30
1974	69	11	1.18
1975	60	12	1.08

The confidence bands define the zone within which there is a 90% chance that the true value for that recurrence interval will lie.

Regional flood frequency curves for Stations WU07 and WU61 were developed according to the method described by T. Dalrymple in USGS Water Supply Paper No. 1683, Magnitude and Frequency of Floods in the United States.

In order to apply the method, the Colorado River Basin is divided into flood frequency regions (A-F) and hydrologic areas (1-13). The two gauging stations were determined to be in flood frequency regions "C" and hydrologic area "13". The drainage area upstream from each gauge was obtained from USGS water-discharge records. Topographic maps (1:250,000) of the Grand Junction, Vernal, and Leadville areas were used to determine the mean altitude of drainage areas by averaging more than thirty elevations obtained at intersections of a superimposed grid system. The mean altitude of the drainage area upstream from Station WU07 was determined to be approximately 7590 feet. The drainage area upstream of Station WU61 has a mean altitude of approximately 7460 feet.

Given drainage area and mean altitude, the discharge of the mean annual flood (MAF) can be interpolated from the curves given in Figure 5.2.1-3. The MAF for Station WU07 was found to be 330 cfs while the MAF for Station WU61 was determined to be 475 cfs. The MAF can also be derived from the equation

$$Q_{2.33} = 0.35\, A^{.74}\, H^{1.5}$$

Where $Q_{2.33}$ is the MAF in cfs, A is the drainage area in square miles, and H is the mean altitude of the basin in thousands of feet above mean sea level.

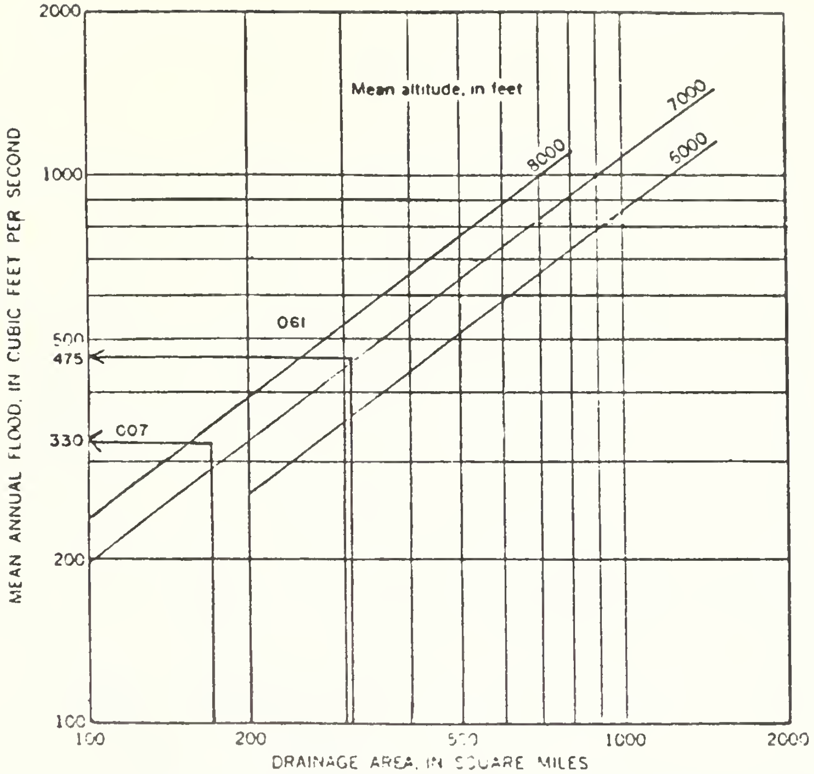


Figure 5.2.1 -3 - Variation of mean annual flood with drainage area and mean altitude in hydrologic area 13.

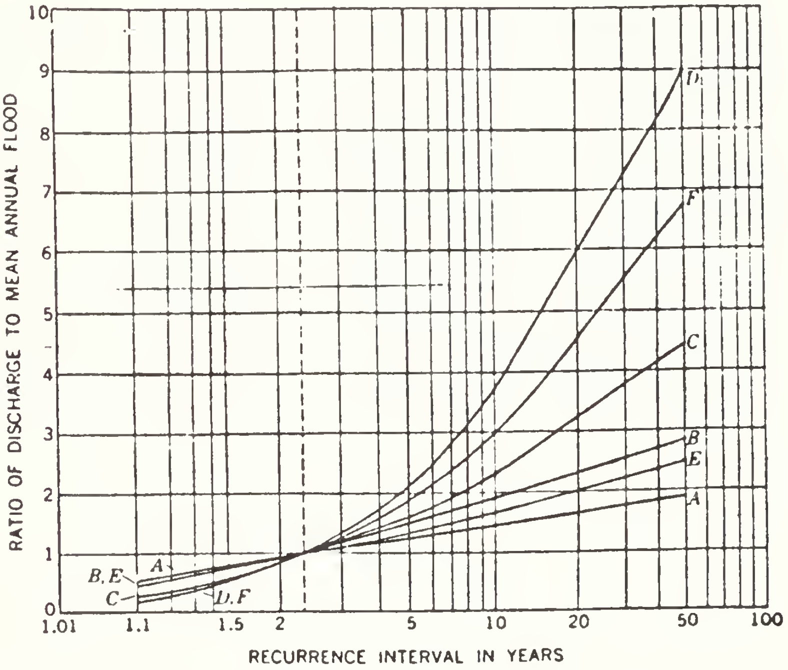


Figure 5.2.1-4 – Composite frequency curves for regions A-F.

The curve for flood frequency region "C" in Figure 5.2.1-4 yields the ratio of the selected recurrence interval corresponding to the MAF. The ratio $\frac{Q}{MAF}$, is multiplied by the MAF to obtain the flood discharge of the desired frequency. (Table 5.2.1-3)

TABLE 5.2.1-3 REGIONAL FLOOD FREQUENCY DATA

Recurrence Interval, years	$\frac{Q}{MAF}$	Station 007 Q, cfs	Station 061 Q, cfs
1.5	0.5	165	238
2	0.8	264	380
5	1.9	627	902
10	2.3	759	1092
20	3.3	1089	1568
50	4.5	1485	2137

Discharges of various recurrence intervals were plotted to sketch the regional flood frequency curves in Figures 5.2.1-5.

Results and Discussion

Annual flood peaks at Station 200 for the period of record have generally been less than 200 cfs. The mean annual flood for the station, approximately 125 cfs, corresponds to a recurrence interval of 2.33 years. In any given year, the MAF has about a 46% chance of being equalled or exceeded.

In a flood frequency distribution, empirical evidence has shown that the discharge corresponding to a 1.5 year recurrence interval will overflow the banks of any given stream. The discharge ($D_{1.5}$) is termed the "bankfull discharge" and corresponds to a flood peak of approximately 100 cfs for the station below Ryan Gulch.

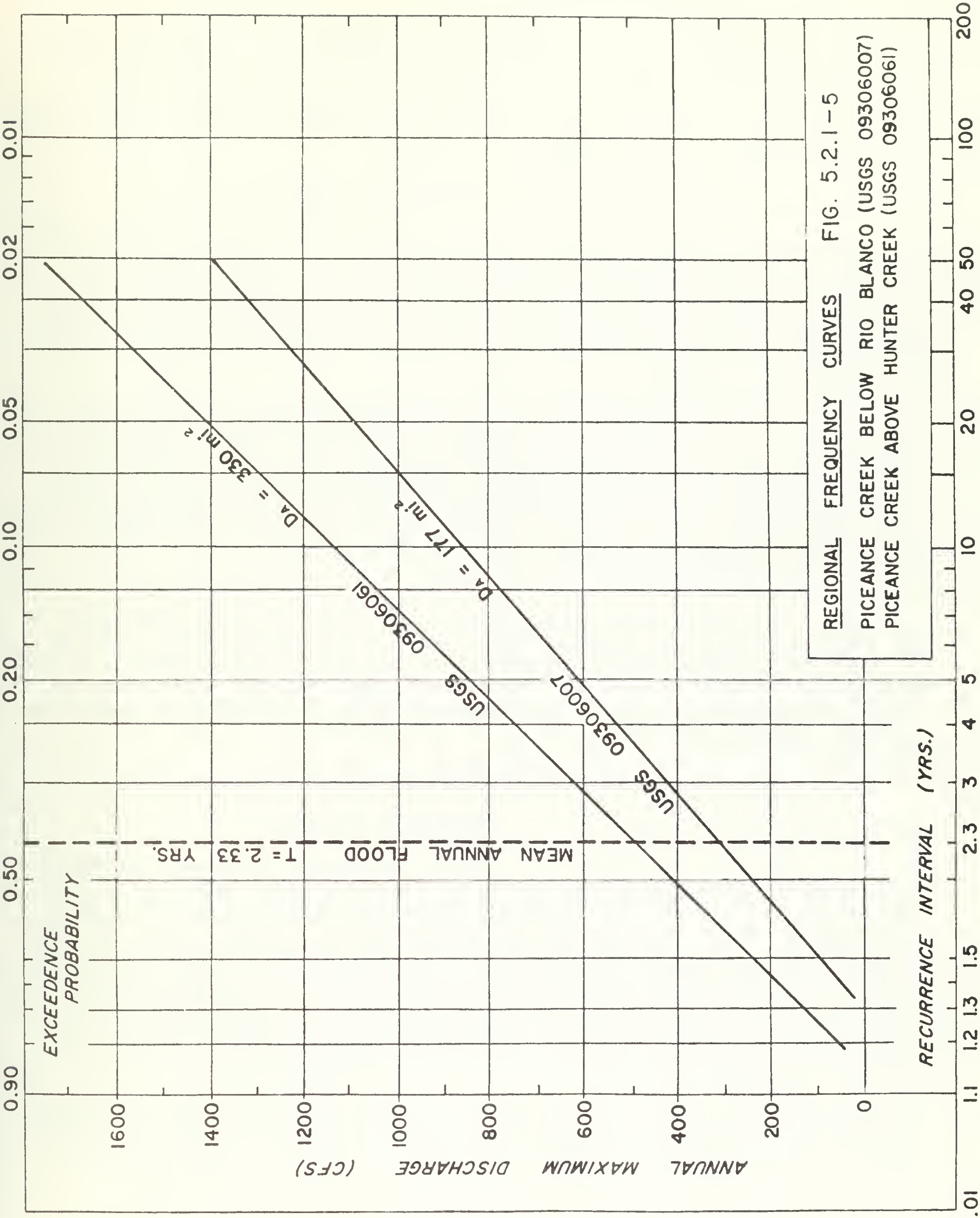
The 400 cfs flood peak of 1966 falls out of the range defined by the 90% confidence bands and thus is assumed to have a recurrence interval greater than the period of record.

Regional flood frequency curves for Stations WU07 and WU61 were obtained in view of the short duration of streamflow records. Slopes of the curves are greater than the slope derived from station data below Ryan Gulch. Topography and precipitation characteristics are comparable at all three stations and the curves should be roughly parallel. The regional curves probably suggest higher discharges for given recurrence intervals than will be observed in future station records. The maximum peak flow recorded for Station WU07 since the gauge became operational in 1974 is 520 cfs (July 19, 1977). The maximum peak flow at Station WU61 occurred September 3, 1977 and measures 492 cfs.

5.2.1.4.3 Stream Flow: Minimum Flow Analysis

Methods of Analysis

Extreme low flow at a station for periods of various lengths may be averaged and subjected to frequency analysis in the same manner as flood peaks.



REGIONAL FREQUENCY CURVES FIG. 5.2.1-5

PICEANCE CREEK BELOW RIO BLANCO (USGS 09306007)
PICEANCE CREEK ABOVE HUNTER CREEK (USGS 09306061)

Periods of 1 day, 7 days, 14 days, 30 days, and 60 days were studied for each year of record for Station 200 to determine the lowest flow average over each respective period. The annual seven-day minimum flow averages were ranked and recurrence intervals were calculated. The plots of discharge versus recurrence interval were used to sketch the seven-day minimum flow curve as well as the other curves shown in Figure 5.2.1-6.

Results and Discussion

For eleven years of record, one-day minimum flows ranged from less than 1 cfs to approximately 13 cfs. For any given year there is a 50% chance that the one-day minimum flow will be less than 2.5 cfs (R.I. equals two years). Similarly, the sixty-day minimum flow average for any given year has a 50% chance of being less than 8 cfs. As the period of record lengthens, the predictions of discharges will better correspond to their true recurrence intervals.

Survival of stream biota is predicated on maintenance of certain minimum stream discharges. Low flows of lengthy duration can also concentrate water quality parameters in a manner that may also endanger aquatic organisms. Any assessment of the impact of oil shale development on water quality must take into account natural tendencies which may also have adverse effects. Minimum flow analysis thus enables prediction of low flow events which may threaten the stream habitat while also providing instructive information for use in setting effluent standards for various parameters.

Irrigation is a major factor contributing to low flow. Piceance Creek water is diverted to irrigate hay meadows, primarily April through September, although in years of favorable temperatures irrigation may extend into November. In some instances, the entire flow of the Creek is diverted onto the fields, reducing visible streamflow to near zero or completely dewatering downstream reaches for varying lengths of time.

5.2.1.4.4 Water Quality

Methods of Analysis

Class 1 water-quality-related variables for stations WU07, WU22, WU58, and WU61 have been plotted as time series and are reported in Appendix B. Two groups of parameters were selected for time series trend analysis of monthly averages from these stations. The first group of data is comprised of monthly values of pH, boron, fluoride, and arsenic for the period October 1974 - May 1978. Trend analysis of flow, phenol, molybdenum, sulfate, and sodium concentrations are based on data obtained monthly during the period October 1974 - June 1978. In the event of missing data, linearly-interpolated values are substituted because time series analyses require data values for each time period.

The Box-Jenkins process features an identification stage which allows the user to specify the number of autoregressive and moving average parameters from the plots of the autocorrelation function (ACF) and the partial autocorrelation

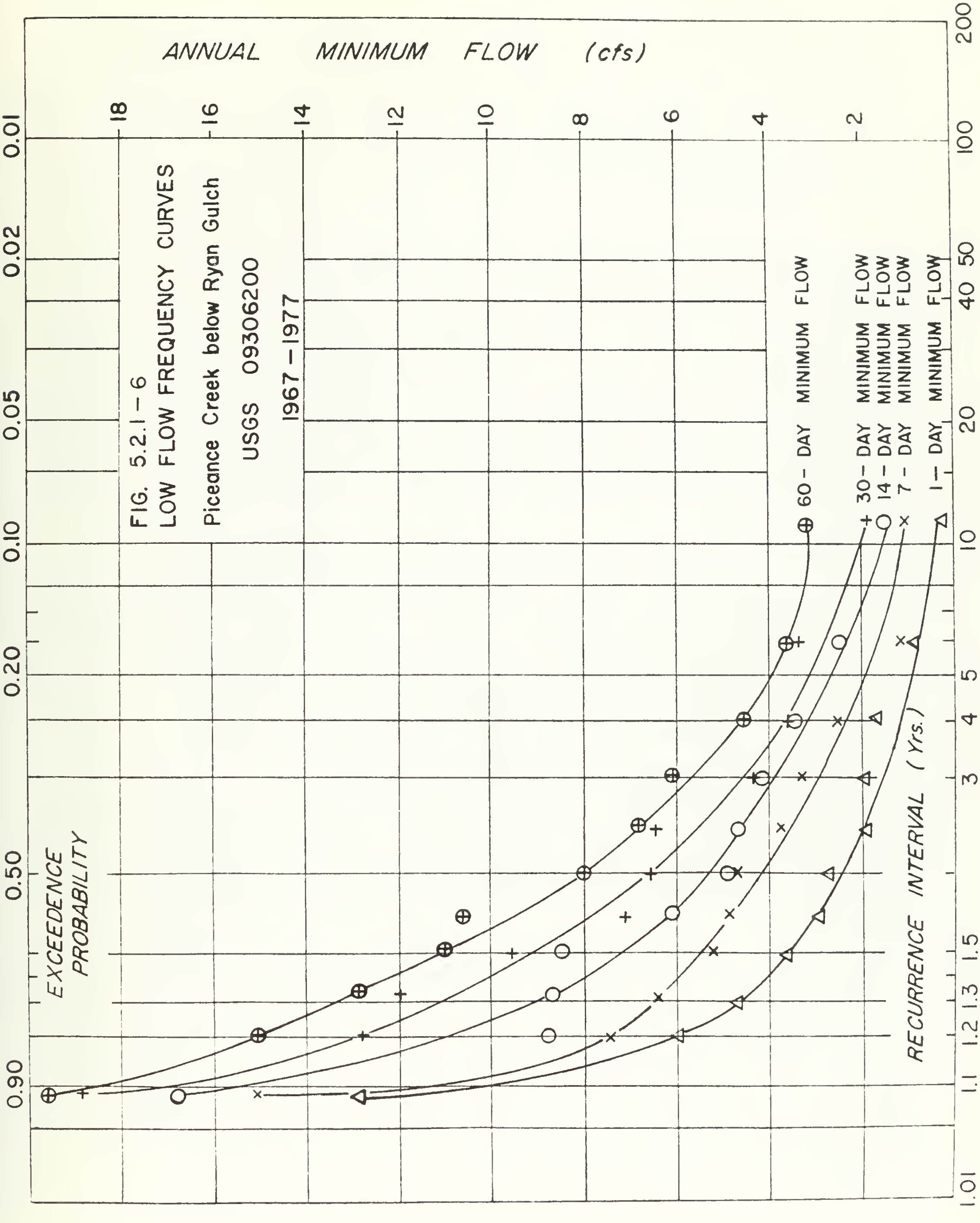


FIG. 5.2.1 – 6
LOW FLOW FREQUENCY CURVES

Piceance Creek below Ryan Gulch

USGS 09306200

1967 – 1977

function (PACF). Parameter estimation, forecasting, and diagnostic checking constitute the second stage. If the model is over-specified, non-significant parameters are removed and the model respecified. Diagnostic checking involves determining that the mean of the residuals is within reasonable confidence limits of zero and that there are no significant terms in the ACF of the lagged residuals. The program provides a chi-square test in order to test the latter hypothesis. Appendix A5.2.1D presents a summary of the Box-Jenkins Time Series Analysis Techniques.

For station-to-station comparisons, mean values of the parameters, specific conductivity, total dissolved solids, pH, arsenic, boron, fluoride, molybdenum, phenol, sulfate, and sodium were analyzed using T-test to facilitate comparison of the equality of the population means between stations. The procedure computes T-statistics testing the above hypothesis assuming both equal and unequal variances. The probability associated with the T-statistics using unequal variances is used to determine acceptance or rejection of the null hypothesis (means not equal). A 90% confidence limit was selected, such that the null hypothesis is accepted if the probability of the two means being equal (PROB>T) is 0.1000 or less. For each location and variable, the number of observations, mean standard deviation, standard error of the mean, and the range of values are provided. An F-statistic is also computed to test for equality of the two variances.

Results and Discussion

Appendix A5.2.1A contains the results of time series analyses performed on pH, boron, fluoride, and arsenic using Box-Jenkins techniques. None of the time series analyses indicated the presence of a significant trend parameter. Forty-four data points appear to be insufficient to generate a seasonal (lag 12) moving-average parameter. In most cases, the seasonality parameter was forced in order to improve the forecasts. The seasonal parameters are expected to become significant as more data become available.

Flow, sulfate, and sodium concentration data were analyzed with the OXY Box-Jenkins model. The results are presented in Tables A5.2.1A-1 to -3. Both a seasonal (lag 12) moving average and a trend parameter proved insignificant in all of the analyses. The available data exhibit no seasonality characteristics or trends over time; i.e. the series mean value best characterizes the data. A model with an autoregressive parameter at lag one fits the data satisfactorily as indicated by the insignificance of the residuals (Chi-square test). Two exceptions occur, the first being the sulfate concentrations at Station WU07 which has an autoregressive parameter at lag four and the second being the sodium concentrations at Station WU22 with autoregressive parameters at four and eight. No explanation for these time lags can be made except that the analysis identifies them as significant to the model.

The water quality parameters selected for analysis thus show no overall trends over time. Predictions based on the available data can best be approximated using the time series mean as shown by the low chi-square value of the original data. Seasonality is not evident in the available data and autoregressive models explain the observed series.

Station-to-station comparisons were made with USGS Stations WU07, WU22, WU58, and WU61. For each pairing of these stations, the acceptance of equal means was variable for the parameters examined. No clear-cut spatial relationship between these stations can be identified because of the inconsistency of the results. Significant change between stations for the various parameters is summarized in Table 5.2.1-4. In the table, an "A" indicates acceptance of the null hypothesis that the means are unequal. Fluoride (F) and sulfate (SO4) show unequal means between each pair of stations. The remaining parameters have some stations indicating differences in means.

5.2.1.5 Conclusions

Available streamflow data allow limited predictions of mean annual flow, peak flows, and minimum flows on Piceance Creek. During the period of record, mean flow was observed to be about 10 cfs at Station WU07 and about 15 cfs at Station WU61. Streamflow records of the station below Ryan Gulch indicate the mean of annual peak flows is approximately 125 cfs. Stations WU61 and WU07 might be expected to exhibit a smaller mean insofar as they are upstream and drain smaller areas. Minimum flow analysis suggests that Piceance Creek discharge averages less than 20 cfs for periods as long as 60 days in any given year. One-day minimum flow averages may be less than 1 cfs. Reed identifies irrigation as a major cause of low flow during growing season.

Time series trend analyses and station-to-station comparisons of water quality were hampered by the paucity of data; no trends have been found to date. As the data base is enhanced, statistical evaluation of trends is expected to become more meaningful.

5.2.2 Springs and Seeps

5.2.2.1 Scope and Rationale

Ten springs provide data for flow and water quality analysis on and in the vicinity of C-b Tract. The springs, shown in Figure 5.2.2-1, correspond to the following station codes: WS01, WS02, WS03, WS04, WS06, WS07, WS08, WS09, and WS10. Discharge from springs in the Uinta Formation may be affected as shafts are developed and dewatered. The monitoring frequency was increased to weekly beginning February, 1979 to better gauge the impact of shaft dewatering. The same indicator variables used to analyze the USGS station data are examined.

5.2.2.2 Objectives

The primary analysis objective is to determine the effect of development and dewatering on spring water quantity and quality. Water level data are insufficient for analysis purposes at this time. Quality parameters are examined for possible time trends and for differences between stations over the development period.

5.2.2.3 Experimental Design

Under natural conditions, the quality of surface

Table 5.2.1-4

T-TEST PROCEDURE SUMMARY FOR BETWEEN-STATION COMPARISONS
OF WATER QUALITY PARAMETERS AT USGS STATIONS

Variables	Stations 6007-6022	Stations 6007-6058	Stations 6007-6061	Stations 6022-6061	Stations 6058-6061	Stations 6058-6022
pH	R	A	R	R	A	A
B	A	A	R	A	A	R
F	A	A	A	A	A	A
As	A	A	R	A	R	R
Mb	R	R	R	R	R	R
SO_4	A	A	A	A	A	A
Na	R	R	A	A	A	R
NH_3	A	R	R	A	A	R
Spec Cond	A	A	A	R	A	A
TDS	A	A	A	R	R	A

Note: Table entries indicate acceptance (A) or rejection (R) of null hypothesis.
Ho: The paired station means are not equal. (90% confidence limit)

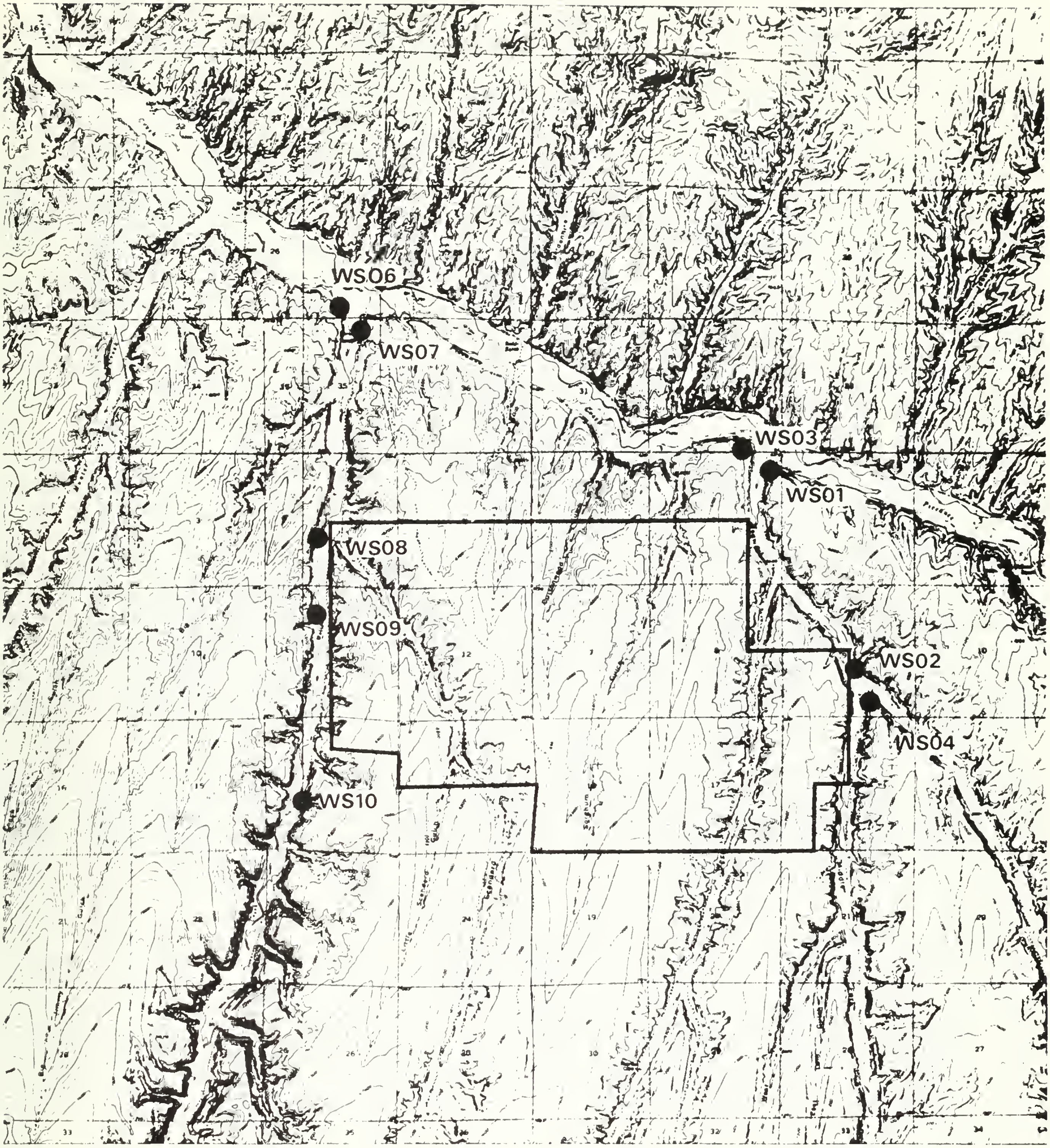


FIG. 5.2.2 - 1 SPRINGS & SEEPS AROUND Cb TRACT

water in springs and seeps was changed slowly but perceptibly with time as was demonstrated by the baseline data. Rates of change are related to rates of flow, which are determined by hydro-geologic considerations. Some groundwater basins unaffected by man show annual fluctuations in quality produced by seasonal variations in precipitation, aquifer recharge, water table levels, and discharge rates. The influence of man and industrial development is often marked as an increase in the amplitude of annual variation in quality along with a progressive decrease in average quality. To observe this change, if it does occur, indicator variables are analyzed for time trends and differences between stations. Multiple correlations and linear regression between parameters are used to test the following hypothesis: 1) dewatering will not affect water quality and quantity of springs and seeps, and 2) construction has no affect on water quality.

5.2.2.4 Method of Analysis

A linear regression is performed on the periodic observations of the various water quality parameters.

The independent time variable, YRMO, includes year and month information with the value being incremented for each month of a particular year; e.g. 74.0 represents January 1974. In order to test the hypothesis that the slope of the linear regression line is zero, two parameters from the SAS General Linear Models (GLM) procedure are examined.

The first test is to compare the model's estimate of the slope with the corresponding standard error of the estimate. The T-statistic at a 95% confidence interval with the appropriate degrees of freedom is then obtained from T-statistic tables. A 95% probability exists such that the true value of the estimate lies in the range ($m\pm \sigma$) where M is the estimate of the slope and σ is the standard error of the estimate. The T-statistic varies for the number of degrees of freedom and is reflected in the range calculations.

The second parameter examined from the GLM procedure is the probability that the slope is not zero. The procedure calculates a T-value for H_0: Slope = 0, from which the probability of the slope having a value significantly different from zero can be obtained.

5.2.2.5 Results and Discussion

Trends Over Time

Trend analysis Tables A5.2.2A-1 through A5.2.2A-7 summarize the results of the statistical analyses of trends. The units for the analyses are milligrams/liter. The small number of observations are the result of the springs being dry for several months of the year. Significant trends identified by station are:

Location WS01 - Both pH and SO_4 values exhibited significant trends. Since the sulfate values are downward-trending, their significance is not of concern. An examination of the data shows that the upward trend in pH values is largely due to a value of 9.2, (abnormally high) recorded in December 1977. Since the previous observation was taken in October

1976, it is difficult to conclude if the high value was a result of steadily increasing pH values or an isolated, perhaps spurious value.

Location WS02 - All slopes were non-significant, except for sodium, Na, which shows a positive trend. However, again only five observations were taken and the last observation, which was substantially higher, precipitated the trend. Subsequent observations are therefore needed to find out if the higher values persist.

Location WS03 - Values for boron, sodium and molybdenum show negative trends, which are not critical and probably are a reflection of some high measurements taken in October 1974.

Location WS04 - Data were not analyzed because all parameters consisted of four or less observations.

Location WS06 - No significant trends are detected.

Location WS07 - No significant trends are detected.

Location WS08 - Data were not analyzed because all parameters consisted of four or less observations.

Location WS09 - Boron was the only parameter showing a negative trend responding to high values reported in Fall of 1974 and 1975.

Location WS10 - Substantially higher sulfate and arsenic readings in December 1977 and June 1978 display positive (upward) trends. Subsequent sulfate and arsenic analyses at this station will determine if this upward trend continues.

Trends Between Stations

Comparison of the Means-between-Stations, Table 5.2.2-1, summarizes the results of statistical hypothesis that mean values between stations are different.

5.2.2.6 Conclusions

The statistical analysis suggests water quality of springs has not significantly changed over the baseline and subsequent development period. A few isolated statistical trends can be satisfactorily explained by the paucity of data or by abnormally high or low values (which are probably spurious). As more data become available, the statistical reliability will improve with a resulting increase in confidence of the results.

5.3 Ground Water Studies

5.3.1 Alluvial Wells

5.3.1.1 Scope and Rationale

Data from alluvial wells corresponding to station

Table 5.2.2-1

T-test Procedure Summary for Between-station Comparisons of Springs and Seeps

Variables	Locations WS01-WS03	Locations WS01-WS06	Locations WS01-WS07	Locations WS03-WS06	Locations WS03-WS07	Locations WS06-WS07
pH	R	R	R	R	R	R
B	R	R	R	R	R	R
F	R	R	R	A	R	R
As	R	R	R	R	R	R
Mb	R	R	R	R	R	R
SO_4	R	R	R	R	R	R
Na	R	R	R	R	R	R
NH_3	R	R	R	R	R	R
Spec Cond	R	R	R	R	R	R
TDS	R	R	R	A	R	R

Note: Table entries indicate acceptance (A) or rejection (R) of null hypothesis
Ho: The paired station means are not equal. (90% conficence limit).

codes WA01-WA12 are analyzed to test for possible changes in water level and selected quality parameters. The indicator variables defined in Section 5.2.1 are selected for statistical analysis. Figure 5.3.1-1 shows the location of the alluvial wells, which monitor each drainage in the C-b Tract vicinity.

5.3.1.2 Objectives

Objectives of alluvial well data analysis are detections of (1) significant rise or fall in water levels in wells, which might be attributed to pond seepage or dewatering, and (2) water quality trends over time or changes between stations during development of the Tract.

5.3.1.3 Experimental Design and Data Analysis

In order to characterize changes in alluvial aquifers, monthly measurements of water level and semi-annual analyses of water quality are presently obtained. Possible effects of surface disturbance, construction, shale pile development, impoundments and dewatering will be evaluated through time-trend and correlation analyses of water quality and quantity parameters.

5.3.1.4 Method of Analysis

(a) Water levels

Monthly water level measurements for four selected alluvial wells (WA03, WA05, WA06, and WA08) were analyzed for time trends and for differences between level measurements using standard statistical null hypothesis tests.

Time series plots of the water level data are also presented and qualitatively interpreted.

(b) Water quality

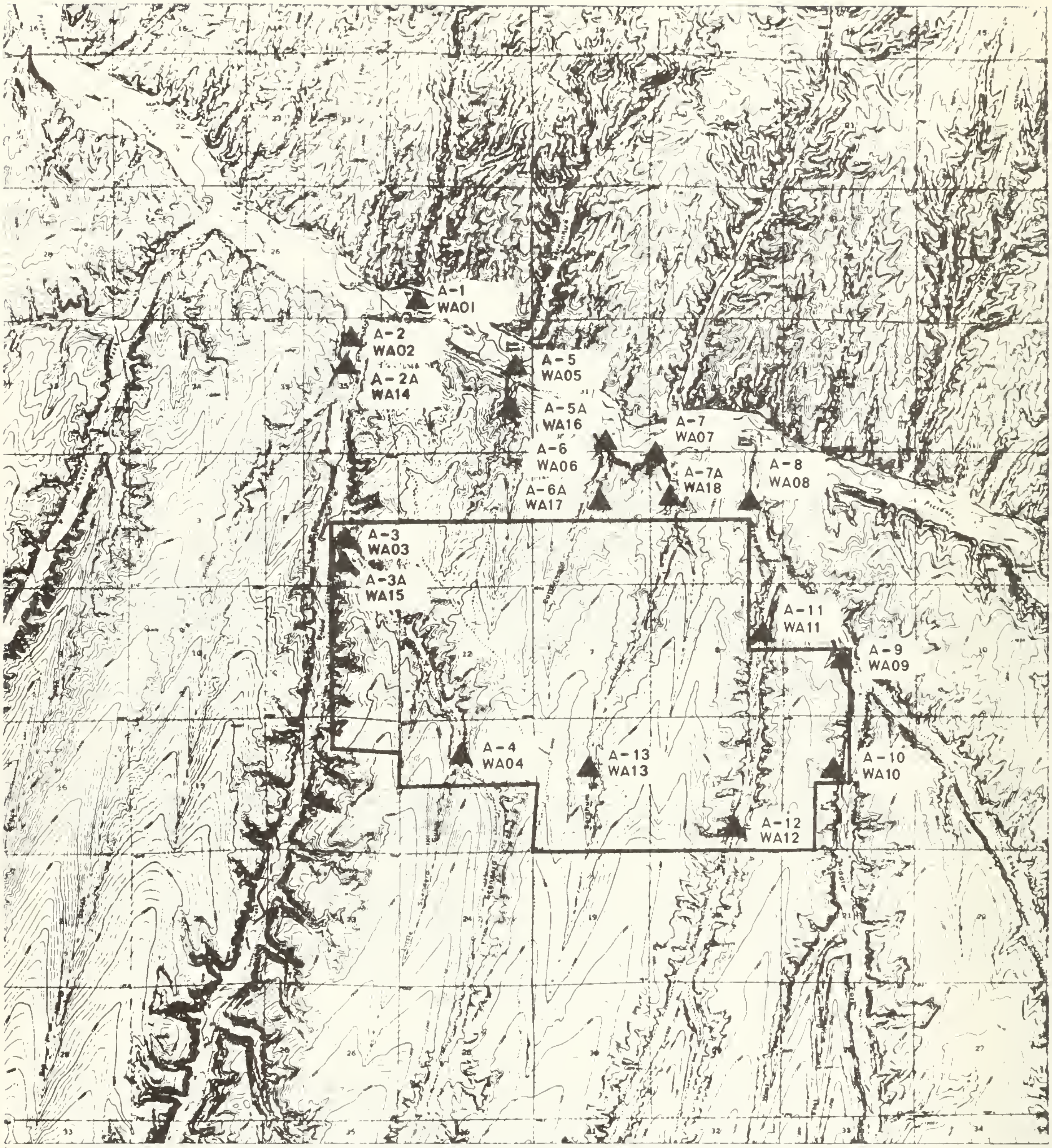
The statistical analysis of trends was accomplished by linear regression techniques which are described in Section 5.2.2.4. Parameter means between stations are compared by T-test for Class 1 indicator variables and stations only.

Frequency of data collection has varied from 0-3 observations per year. The irregularity and scarcity of data indicate that subjective evaluation of either abnormally high or low values should be made prior to drawing conclusions.

5.3.1.5 Results and Discussion

(a) Water levels

Time series plots of water level in four selected alluvial wells (WA03, WA05, WA06, and WA08) are presented in Appendix B as Figures B5.3.1-13, B5.3.1-14, B5.3.1-15, and B5.3.1-16. Qualitative interpretation of the figures indicates a possible trend toward lower water level in well WA03. The data suggest an annual cycle with highest water levels occurring in July and lowest water levels occurring in April. WA05, however, remained relatively constant across all months. Year 1977 shows lowest annual average level possible reflecting the low precipitation occurring that year.



ALLUVIAL AQUIFER MONITORING NETWORK WITH PROPOSED NEW ALLUVIAL WELLS A-2A, A-3A, A-5A, A-6A, A-7A

FIGURE 5.3.1.-1

Linear regression analysis was used to calculate the regression of water level with time. The hypothesis that the slope of the regression line is zero was tested for each of the same four wells. The hypothesis was accepted at the 5% level of significance for all wells indicating the samples statistically could have been taken from wells with no time trend. Results are shown in Appendix Table A5.3.1A-12.

Comparison of the mean water levels in the four wells resulted in rejecting hypotheses of equal water levels in paired comparisons except for wells WA05 and WA06 which accepted the hypothesis. Tests were made at the 5% level of significance.

(b) Trend Analyses

The results of trend analyses are tabulated for each well in Appendix Tables A5.3.1A-1 - A5.3.1A-11. Units are milligrams per liter. A brief summary is presented below:

Station WA01 - No significant trends were detected for any of the indicator variables except for sulfate (SO_4) concentration. However, the trend is not critical because it is negative and does not reflect higher concentrations with time. An examination of the data shows that the SO_4 concentrations were relatively constant over the baseline period (1976), but dropped sharply in a March 1978 measurement. The low measurement, coupled with a relatively high value in October 1974, precipitated the statistical trend.

Station WA02 - No significant trends were detected. The small number of observations of each parameter results in very wide confidence intervals, but the observations are evenly spaced such that no bias exists in the system.

Station WA03 - Both fluoride and sodium concentrations exhibit significant trends which slope downward, indicating no contamination of the ground water. An abnormally high value for sodium was obtained in October 1974 which was approximately twice the value observed in subsequent measurements made in 1976 and 1978. The same is true for fluorine, which had a value of 1.90 in October 1974 and values approximately 0.40 in subsequent analyses.

Station WA05 - The parameters showed no significant trends with time. A maximum of six observations were made.

Station WA06 - The following parameters had slopes significantly different from zero: B, F, SO_4, Na. They are all negative slopes; thus no increase in parameter concentration is indicated. High parameter values recorded in October 1974 caused the trends to appear.

Station WA07 - The analyses of B, F, and Na indicate a trend in a negative direction.

Station WA08 - No significant trends are detected.

Station WA09 - No significant trends are detected.

Station WA10 - The SO_4 concentrations show a negative trend. However, the molybdenum analyses show a positive trend. A very low value was recorded for molybdenum in October 1974 followed by more or less constant readings for the next four observations. The abnormally low value dictated the upward trend since there were only five observations. The data indicate that the resulting upward trend was not caused by consistently higher values with time. If the low value is considered spurious, then the remaining four observations do not constitute a trend.

Station WA11 - No significant trends are detected.

Station WA12 - No significant trends are detected.

(c) Comparison of Station Means

Appendix Table A5.3.1A-12 summarizes the results of T-test comparisons of parameter means. The comparisons are limited to the four stations identified as Class 1 indicator variables in Section 4.2.1.

With few exceptions, the null hypothesis is rejected between alluvial well locations indicating no significant changes in mean values of water quality parameters. The means of all ten parameters are not significantly different between locations WA03-WA05 and WA05-WA08. Specific conductance displayed significantly different means between the following location pairs: WA03-WA06, WA03-WA08, WA06-WA05, WA06-WA08.

5.3.1.6 Conclusions

The statistical analysis of available water quality data shows no overall trends over the period extending from the baseline period to the early part of 1978. Conclusions reached through this type of analysis are tentative due to the low frequency of data collection and consequent paucity of data.

Comparison of means between stations showed no significant differences for most comparisons. The notable exception is for specific conductance, which showed differences in four of the six comparisons.

5.3.2 Upper Aquifer (UPC_1, UPC_2) and Lower Aquifer (LPC_3, LPC_4)

5.3.2.1 Scope and Rationale

Data from gross water-bearing intervals above and below the Mahogany Zone were reviewed to assess changes in water level as well as water quality at various depths over time.

5.3.2.2 Objectives

Water level characteristics of aquifers above and below the Mahogany Zone will be compared to levels obtained after the onset of dewatering operations initiated in early 1979. Water level contour maps for 1976-1978 thus provide baseline information.

Water quality at the various depths over time is assessed for statistical significance for the following parameters: specific conductance, boron, aluminum, potassium, total dissolved solids, calcium, sodium, ammonia, and magnesium. The data presented are indicative of baseline conditions since subsurface activities (i.e. shaft-sinking) were not initiated until early 1979.

5.3.2.3 Experimental Design

Water level contour maps were generated for the two intervals to observe changes in head of the respective aquifers during the period November 1976 - November 1978. Well locations are given in Figure 5.3.2-1.

Five succeeding deeper intervals in the UPC_2 and the LPC_3 zones were analyzed for changes in water quality during the period 1976-1977. In the UPC_2 zone, analyses of water quality in succeedingly deeper open intervals in the well completions of SG-9-2, Cb-2, SG-11-3, AT-1C-3, and Cb-4 were used. Water quality parameters characteristic of AT-1C-1, which is open to the LPC_3 zone, were also analyzed.

5.3.2.4 Method of Analysis

(a) Water levels

Water level contour maps were generated on a monthly basis for the water-bearing zones above and below the Mahogany Zone. Contours are drawn at 50-foot intervals on base maps showing the C-b Tract boundary and well locations with corresponding water levels. A representative map of the Upper Aquifer is given in Figure 5.3.2-2. Additional plots are compiled in Appendix A5.3.2B. Plots for certain months are not given due to missing data or insufficient data to generate meaningful contours. Contour maps of lower aquifer water levels will be generated at a later date.

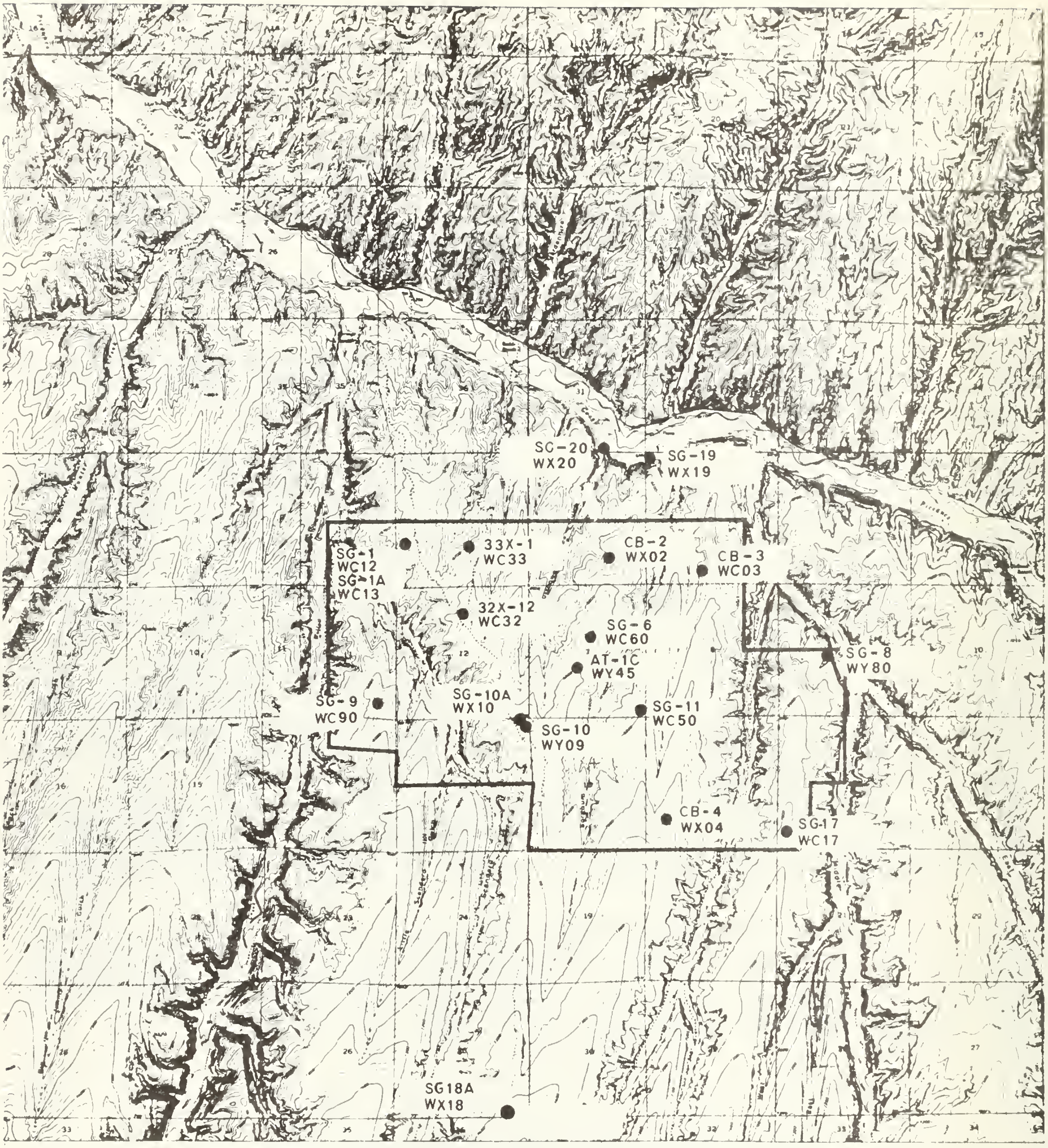
(b) Water quality

Analysis of variance was used in a 5 x 4 factorial design to assess the significance of depth and time on the selected water quality parameters. Originally, the data were organized in a factorial design matrix of the form 2 x 5 x 4 representing level classifications:

2. Aquifer depth levels (UPC_2 and LPC_3).

5. Graduated depth levels within the aquifer

4. Time Periods (1974, 1975, 1976, 1977).



DEEP WELL MONITORING NETWORK
C-b TRACT
FIG. 5.3.2-1

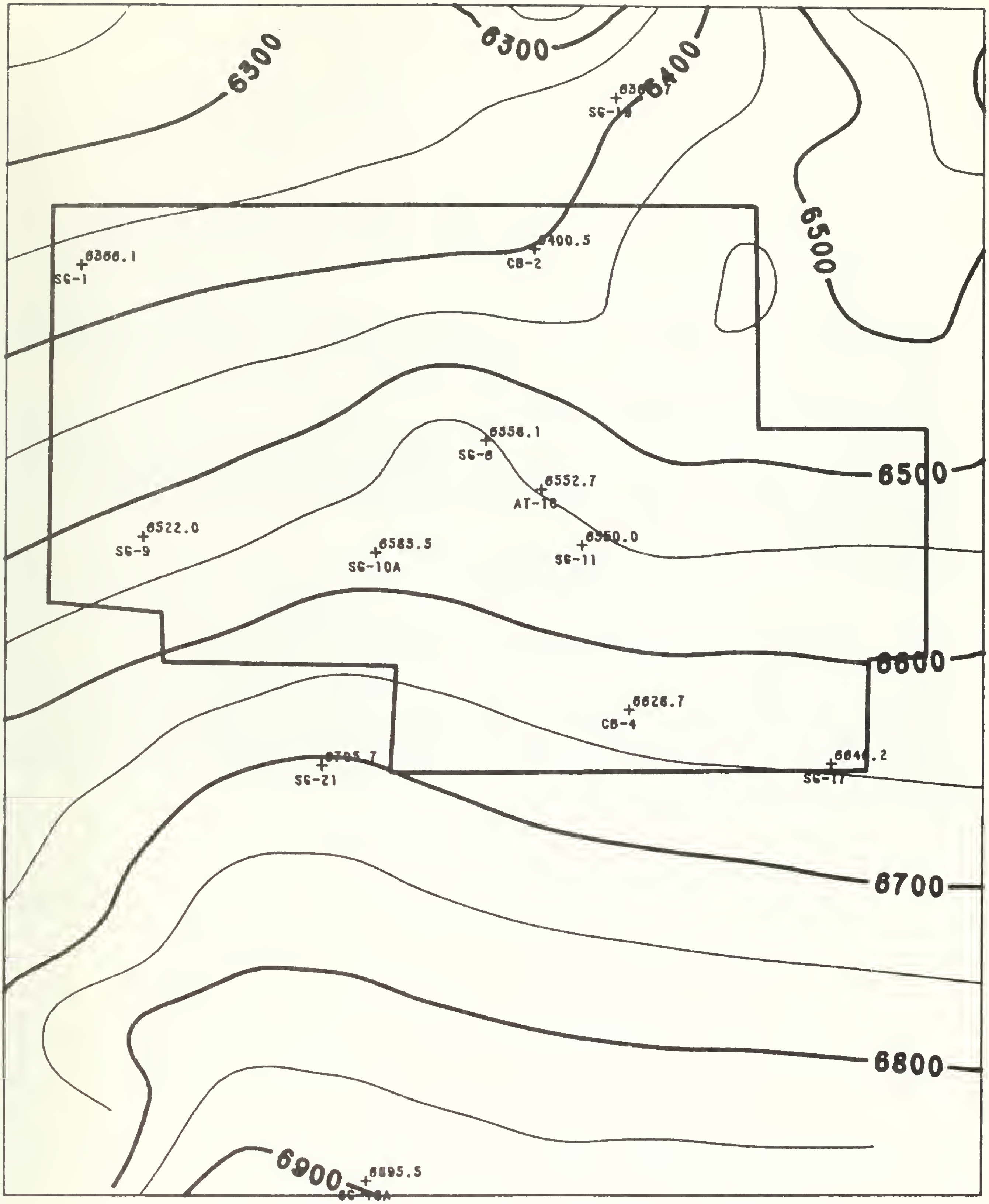


Figure 5.3.2-2 Potentiometric Surface Map - Upper Aquifer November 1976

Incomplete data precluded use of aquifer depth levels so that the data were analyzed for depth and time trend only. Groups of data which have missing data points have been omitted from analyses and are cross-hatched in tabulated results. The source of variation, sum of the squares, number of degrees of freedom, mean square, and F-statistics were also calculated. A significant ($\alpha = 0.05$) F-Statistic is followed by a double asterisk in these tables.

5.3.2.5 Results and Discussion

Water level contour maps will be used to gauge changes of head in the aquifers during shaft-sinking and mining dewatering operations.

Tables A5.3.2A-1 through A5.3.2A-9 summarize the analysis of variance for the groundwater quality parameters. All parameters, with the exception of boron, have non-significant F-values with respect to time such that no trend exists over time. Boron shows a reduction in concentration with time suggesting that no adverse changes are indicated.

The analysis shows that the specific conductance, potassium, total dissolved solids, calcium, sodium, and magnesium show trends with increasing depth. The wells completed in the UPC_2 zone show higher concentrations than the well completed in the LPC_3 zone.

5.3.2.6 Conclusions

Water levels exhibit small fluctuations over time such that changes due to dewatering will be readily detected.

Bedrock wells show no significant signs of diminishing water quality over time. The depth relationships, although ascertained with a small amount of data, seem to indicate a lack of communication between the aquifers above and below the Mahogany Zone. Station-to-station comparisons are achieved through ordering of the data according to depth.

6.0 AIR QUALITY AND METEOROLOGY

6.1 Introduction and Scope

The lease stipulated that, during Baseline, air quality be monitored over the entire lease year at four locations for sulfur dioxide, hydrogen sulfide, and suspended particulates using continuous recorders where applicable. The Lessee was also required to monitor hydrocarbons, oxides of nitrogen, and other pollutants. The Lessee was also required to establish a meteorological tower with multilevel instrumentation for measurements of wind speed and direction, relative humidity, and temperature. Subsequent conditions of approval imposed by the Area Oil Shale Supervisor required that upper air studies of temperatures and wind profiles, visibility studies and noise studies be conducted. Initial lease requirements, modified during baseline, required operational performance efficiency of 90 percent for air quality and 95 percent for meteorology.

To satisfy the conditions of the lease and provide additional data, five air quality trailers, a 200-foot meteorological tower, three mechanical weather stations, two acoustic radars, aircraft, free-flying and tethered balloons, special chemical analyses for trace metals, visibility by photometry and sound-level measurement techniques were utilized.

For Development Monitoring, hydrocarbons are no longer required to be monitored, the number of air quality trailers has been reduced from five to two, mechanical weather stations from three to two, acoustic radars from two to one and trace metal studies were deleted.

Section 6.2 describes the current air quality program and 6.3 the supporting meteorological program.

6.2 Ambient Air Quality

6.2.1 Gaseous Constituents

6.2.1.1 Scope and Rationale

Continuous monitoring of gaseous components of ambient air on and near the C-b Tract has included:

Sulfur dioxide
Carbon monoxide
Ozone
Hydrogen sulfide
Oxides of nitrogen
Nitrogen dioxide
Nitric oxide

The monitoring of these is required by the Lease stipulations and under the State and Federal air quality regulations. Data collected since November 1, 1976 have been reduced and analyzed for trends and shifts from the baseline.

6.2.1.2 Objectives

The objectives of the analyses reported here are: a) to demonstrate compliance with applicable regulations; b) to examine potential long-term trends from baseline; c) to provide a general air quality status assessment; d) to identify potential sources of pollutants; e) to evaluate the significance of monitoring data.

6.2.1.3 Experimental Design

The air quality development monitoring network is shown in Figure 6.2.1-1. Environmental baseline data collection ended October 31, 1976. Starting with November 1, 1976 air quality and meteorological data have been collected continuously at the meteorological tower and air quality trailer site AB23 (formerly 023) located on the C-b Tract. Precipitation data have been taken continuously at Piceance Creek air quality trailer sites AB20 and AB23. Meteorological and air quality monitoring was resumed at this site (AB20) in February 1978. Also commencing in February 1978, two additional sites, AD42 and AD56, were activated to monitor particulates, wind speed, wind direction and ambient temperature. The data collected at each site, the frequency of collection and the start-up dates are shown in Tables 6.2.1-1 and 6.2.1-2.

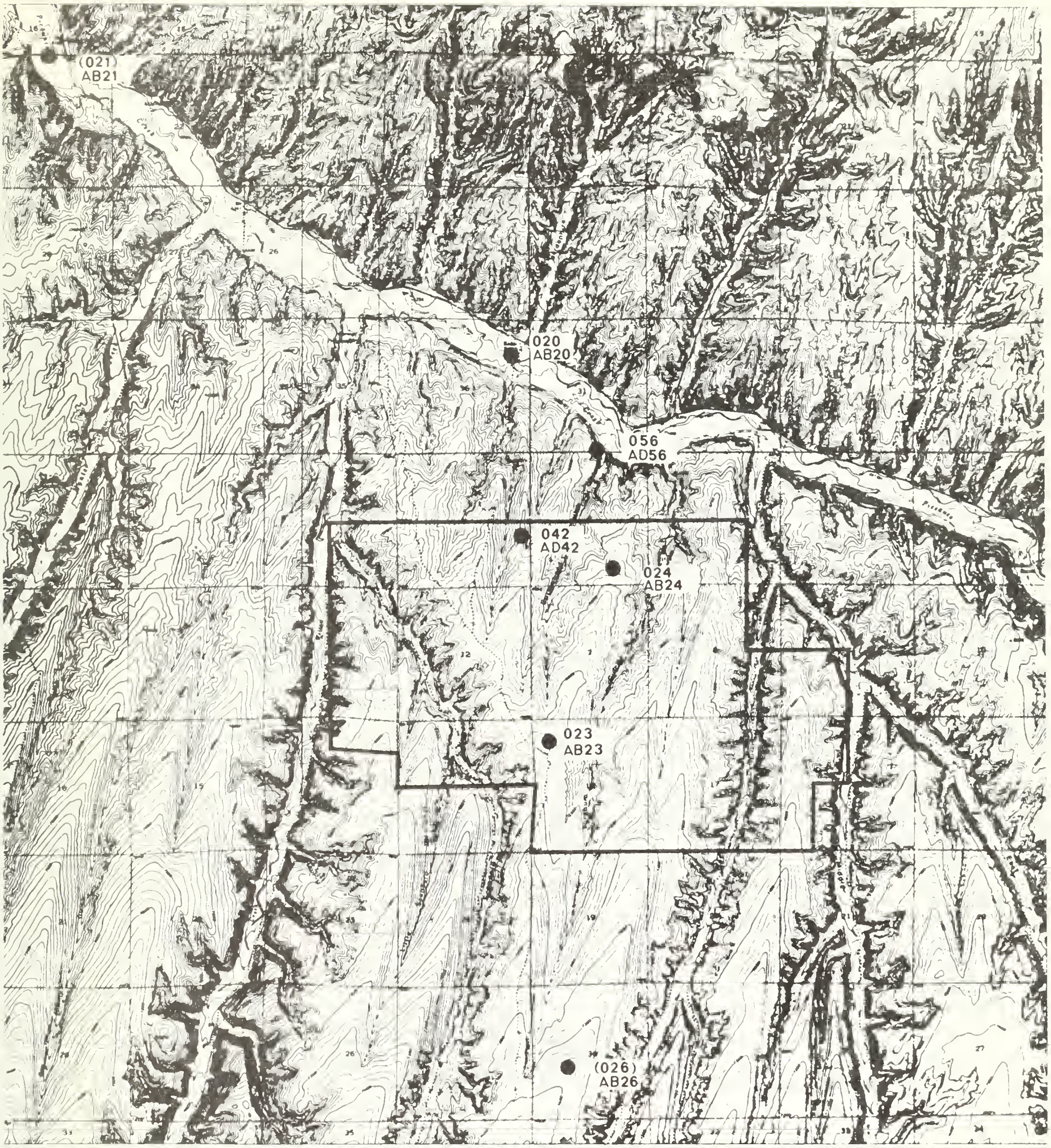
A variety of factors can cause interruptions in continuous monitoring programs such as that undertaken at oil shale Tract C-b. In order to provide visibility to the usable data collected, data timelines are presented in Figures A6.2.1-1 through A6.2.1-4 showing by site, and parameter, the periods since November 1, 1976 for which usable data have been collected. Data collection has continued since September 1978; it is not yet reduced beyond that point.

Monitoring equipment in use has been subject to changes during the period of this report. During September 1978, having discontinued hydrocarbon monitoring, the Bendix gas chromatograph, which had been used for hydrocarbons and carbon monoxide, was retired. To continue monitoring of carbon monoxide, Beckman Model 866 non-dispersive infrared CO analyzers were installed in Stations AB20 and AB23. During March-July of 1977 an improved model of the sulfur gas analyzer previously used was installed in Station AB23 in parallel with the older unit. The new analyzer, a Meloy SA-185-2A has been in use since that time. In January 1978, Monitor Labs Model 8440E NO/NO_x monitors were installed in Stations AB20 and AB23, replacing the Meloy Model NA-520-2 analyzers previously in use. In each of the above changes, the new instrument is an EPA designated reference or equivalent method.

Specifications for all instruments are detailed in Table A6.2.1-1.

6.2.1.4 Results and Discussion

Results are grouped into separate studies and conclusions for each are drawn.



AMBIENT AIR QUALITY DEVELOPMENT MONITORING NETWORK

Note: ( )= Systems Dependent

FIGURE 6.2.1-1

TABLE 6.2.1-1

AMBIENT AIR-QUALITY & METEOROLOGY DATA DESCRIPTION

Symbols represent sampling frequency on Table 6.2.1-2

Measurement: Category and Location	Measurement: Start-up Date	SO_2	H_2S	Particulates (3)	Ozone	NO_x	NO	NO_2 (1)	CO	Horizontal Wind Speed	Horizontal (2) Wind Direction	Vertical (2) Wind Speed	Relative Humidity	Air Temperature	Precipitation (4)	Evaporation	Barometric Pressure	Solar Radiation	Temperature Difference	Mixing Height	Visible Range	Height	SF_6
Air-Quality Trailer																							
020	a) Jan. '78			0						X	X				Z								
	b) July '78				X	X	X	X	Y					X									
	c) 1980	X	X																				
021	Systems Dependent																						
023	Nov. '74	X	X	0	X	X	X	X	Y						Z	S	X	X					
024	a) 1980			0						X	X			X									
	b) 1981	X	X																				
026	Systems Dependent																						
Weather Sta & Hi-Vol Sampler																							
042	Feb. '78			0						Z	Z			Z									
056	Feb. '78			0						Z	Z			Z									
Met. Tower @																							
3m	Nov. '74												X*										
10m	Nov. '74									X	X	X		X					2				
30m	Nov. '74									X	X			X									
60m	Nov. '74									X	X	X		X					2				
Upper Air Studies																							
Minisonde	Oct. '77									W	W			W								W	
Acous. Sound, 020	Oct. '77																			U		U	
Visibility, Sta. 060	Apr. '78																				V		
Tracer Studies	Fall '78																						T

* @ 1m

(1) $(NO_2) = (NO_x) - (NO)$

(2) Std. Deviation calculated.

(3) Also Size Distributions during Visibility Study

(4) These stations also used to obtain waterquality of ppt. measurements

TABLE 6.2.1-2

ABMIENT AIR QUALITY AND METEOROLOGY SAMPLING AND REPORTING FREQUENCIES

Symbols appear on Table 6.2.1-1

Symbol	Sampling Frequency	Minimum Average Time	Minimum Report Frequency	Description
X	10-seconds	5-minutes	1-hour	AQ & Low Alt. Meteorology
Y	5-minutes	5-minutes	1-hour	AQ & Low Alt. Meteorology
Z	Continuous	1-hour	1-hour	Precipitation
0	Every 3rd day	24-hours	24-hours every 3rd day	Particulates
2	20-seconds	5-minutes	1-hour	Temp. difference from 10-meter to 60-meter on Met. Tower
W	Approx. 30-seconds	Approx. 30-seconds	Approx. 30-seconds	Double Theodolite Minisonde
U	14-seconds		1-hour	Inversion Height/Mixing Layer from Acoustic Sounder
V	7 times per day every 6th day for 20 days in Spring and 20 days in Fall	Hourly	Daily (w/hourly max/min.)	Joint Visibility study with C-a from Hunter Creek Site
T	Continuous for approx. 2 days	1-hour	1-hour	SF_6 Tracer Studies for Air Diffusion Model Validation
S	Weekly	Weekly	Weekly	Evaporation

6.2.1.4.1 Data Uncertainty

Scope and Rationale

Much of the gaseous constituent data, with the exception of ozone, represent levels of concentration at or near the measurement threshold of the instrumentation. Data in this range must be interpreted with care due to several factors:

- Constant sources of error such as electronic noise and concentration fluctuations due to pressure and flow fluctuations in the instrument can represent a large percentage of the total output for low concentrations.

- It is generally not possible to calibrate ambient monitors at low concentrations with available calibration equipment.

- Each instrument is subject to a minimum detection level, below which the output can only be interpreted as noise.

In attempting to use such low-level data in correlative or predictive analysis, one must first determine the level of significance of the data as this will have a pronounced effect on the validity of any such analyses. This approach is indicated for the data on sulfur dioxide, hydrogen sulfide, nitrogen oxides, and carbon monoxide.

With respect to ozone, the measured concentrations have typically been well above the measurement threshold of the instrument. Nonetheless, there will be a degree of uncertainty attached to the ozone data which should be known and considered in relation to any data analysis.

Objectives

- To establish bounds of expected error for all gaseous monitoring data.

- To determine criteria of suitability for analysis for each data set.

Method of Analysis

A thorough analysis of data error requires primary information in three discrete areas:

1. Validity of the measurement method (e.g., Flame photometric detection for sulfur gases).

2. Precision of succesive measurements at a constant concentration, expressed as the standard deviation.

3. Accuracy obtainable with the measuring system.

The criterion of method validity rests on the theoretical basis of the method. In the case of ambient air monitors, the methods in use (especially those which are EPA reference or equivalent methods) are generally recognized through experience to be valid for the constituent in question.

The validity of the method is determined by establishing the appropriateness of the chemistry and physics of the analytical method. For instance, SO_2 analyzers using the flame photometric detector systems presume all SO_2 atoms will release the same quantum of energy (E) as a result of excitation by a hydrogen oxygen flame. The assumption is established by the accepted law $E=h_\eta$, where h=Planck's constant and η is frequency of the radiation; hence the validity of the method is determined. The question of equipment response is a different matter, that is for each h_η emitted, the photomultiplier does not necessarily produce a detectable signal. Therefore, the equipment response can be less sensitive than actual physics of the detector. Also, each atom of SO_2 may not reach an excited state thereby biasing the response on the low side. Difficulties with amplifier circuits receiving the photomultiplier output, and attenuating circuits, incrementing the output all contributed to produce a very complex systematic error in measuring h_η.

To establish data scatter, the calibration must be repeated numerous times in order to determine the precision of the analyzer. At least three values for each calibration point should be determined and their standard deviation calculated. The standard deviation is the most reliable index of random error. It should be pointed out that the standard deviation of the mean, δm, is reduced by successive measurements N, according to the relationship $\delta x/\sqrt{N}$. Therefore, it is not necessary to attempt to enhance the precision of each point by making a large number of determinations. If the standard deviation is large, then a review of the procedure would be more useful than making a large number of determinations.

The standard deviation of each series of measurements then represents the instrument's precision at that concentration. Part of the testing required for EPA certification involves this type of procedure. In the analysis presented in this report, manufacturers certified precision values were used due to a lack of information on actual measured precision.

Analyzer accuracy is determined by means of calibration. As applied to air monitors, this involves inputting calibration gas of a known accuracy and precision to the analyzer. The response of the analyzer is then compared to concentration of the standard gas. The resultant accuracy may be expressed as the percentage of the standard represented by the instrument output. The accuracy must be determined over the range of values encountered in ambient monitoring.

Once these basic areas have been analyzed, then the actual error analysis can proceed.

The objective of error analysis is to determine the degree of uncertainty of data from the measuring system, referenced to a specified degree of confidence. For example, a gaseous monitor result might be expressed as $50\pm$ PPB (90%

confidence), meaning that there is a probability of .9 that the result lies between 45 and 55 PPB. Since trends in, and correlations between air quality parameters are often complex functions of many variables, it is desirable to determine the uncertainty in each variable to the maximum practicable confidence level. For this analysis, a confidence level of 95% has been chosen.

Then the problem simplifies to finding the expected standard deviation of system measurements over an appropriate range of concentrations. Assuming that all significant errors are random, then the variability of measurements at a single concentration will follow a normal frequency distribution. For this it follows that 95% of all measurements will be within two standard deviations (2δ) of the mean.

The mathematics of obtaining an overall system standard deviation as a function of component deviations is described in the Appendix in Table A6.2.1-2.

Results and Discussion

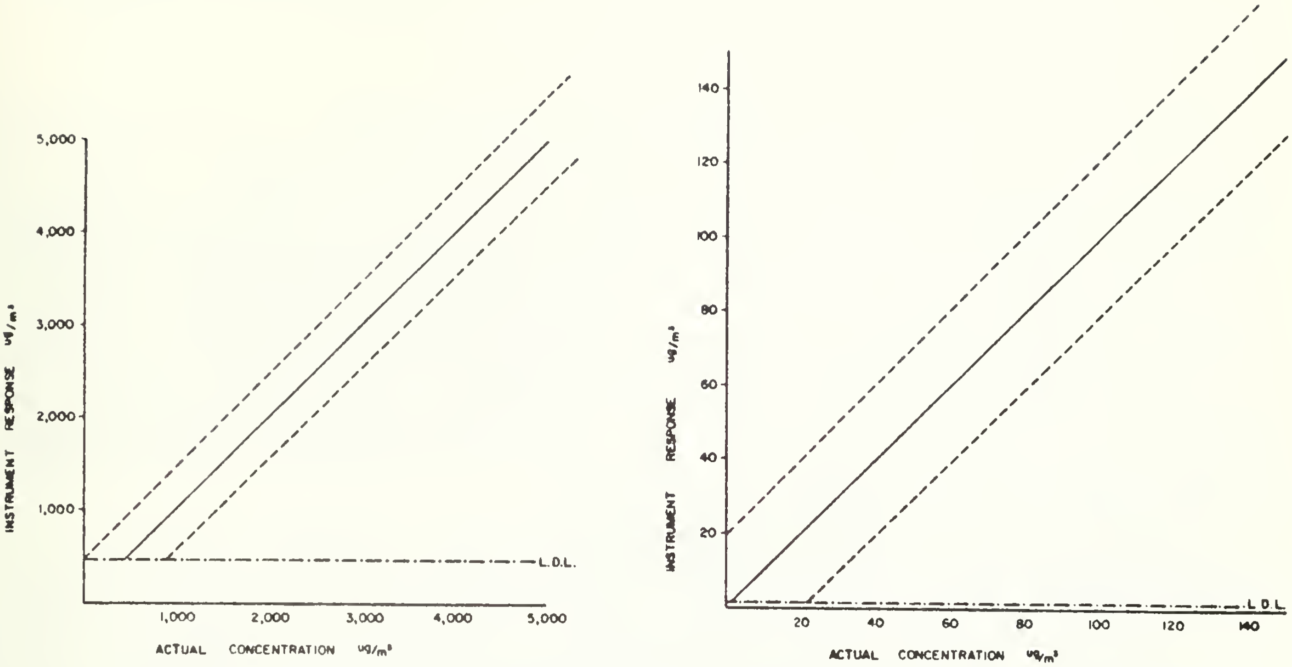
The results of this analysis as applied to each type of gaseous constituent monitor are presented in Figure 6.2.1-2. These plots represent the range of instrument response which would be observed for 95% confidence at a given concentration. The position of the plot relative to the axes is arbitrary, representing an "ideal" calibration. In actual practice, shifts in the slope and intercept of the calibration line might be observed. However, the relative magnitude of error at a given actual concentration would remain as shown.

The plot is not extended below the point where the lower confidence limit intersects the lower detection limit of the instrument. Instrument response below that point cannot be reliably assumed to represent a non-zero concentration.

The variation of expected error with concentration shows a similiar pattern for ozone, carbon monoxide, and nitrogen oxides. In each case, random error due to analyzer precision is dominant over error due to calibration precision. Analyzer precision is given as a fixed percentage of full scale, so it results in a level of error independent of concentration. For the sulfur cases, the error limits are seen to increase with concentration. This is due to the higher level of concentration-dependent calibration error, relative to analyzer precision. Input parameters used in the analysis are listed for each instrument in Table A6.2.1-1.

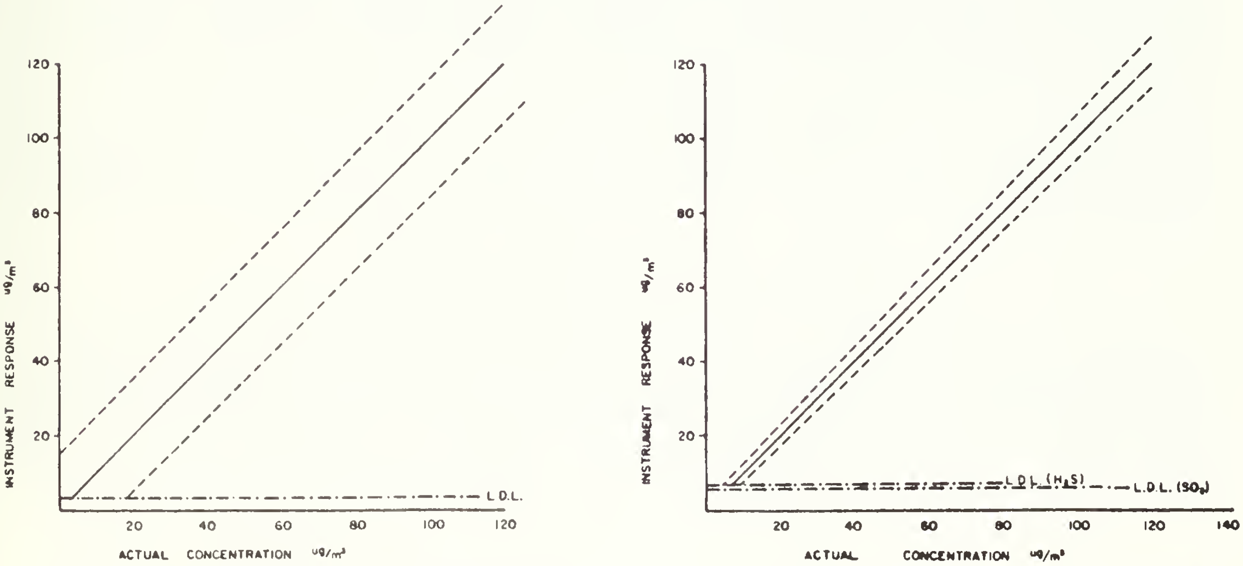
The results presented must be qualified to the extent that most of the inputs are manufacturer's specifications of performance data, which are directly applicable to the average analyzer of that type and model number. Each individual analyzer would, of course, be subject to some variation from this average. An effort is currently under way to obtain primary calibration and precision data for each analyzer, after which this analysis will be repeated.

FIG. 6.2.1-2 - MEASUREMENT ACCURACY OF AIR QUALITY PARAMETERS



CO 95% CONFIDENCE LIMITS vs. CONCENTRATION

O_3 95% CONFIDENCE LIMITS vs. CONCENTRATION



NO-NO_x 95% CONFIDENCE LIMITS vs CONCENTRATION

SO_2-H_2S 95% CONFIDENCE LIMITS vs CONCENTRATION

Conclusions

1. For each analyzer, there exists a response level below which indicated data are not significant at a given level of confidence. At the 95% confidence level the following limits apply:

Table 6.2.1-3 GAS ANALYZER LOWER LIMITS

Analyzer	Lower Limit of Significance
SO_2	8 μg/m^3 (LDL 5 μg)
H_2S	9 μg/m^3 (LDL 7.0 μg)
CO	900 μg/m^3 (LDL 450 μg)
O_3	21 μg/m^3 (LDL 1 μg)
NO, NO_x	19 μg/m^3 (LDL 4 μg) as NO_2

Note that for each analyzer this lower limit of significance is substantially higher than the Lower Detection Level (LDL).

2. Future analyses should be undertaken only when a suitable fraction of data are above the significance limit.

6.2.1.4.2 Concentrations As Time Histories

These discussions generally refer to the corresponding time-series plots, Figures B6.2.1-1 to B6.2.1-12.

Sulfur Dioxide

In March of 1977, an improved version of the existing SO_2 analyzer was installed in Station AB23. This analyzer, the Meloy SA-185-2A carries a designation as an EPA equivalent method, and is distinguished from the older model largely on the basis of sensitivity. On the plot of SO_2 concentration vs time, Figure B6.2.1-2, this change is indicated by a drop in the lower detection limit (LDL) on April 1, 1977. The lower LDL implies a lower noise level, which is evidenced in comparing the plot on either side of the change.

Overall, there has been no significant departure from SO_2 measurements during the baseline period.

Hydrogen Sulfide

Although H_2S is not subject to a National Ambient Air Quality Standard, and therefore does not have an EPA reference method, the analyzers used for SO_2 may be readily used, after a simple conversion to remove SO_2 from the sample gas. Instrument response should then be similiar to that observed as an SO_2 analyzer.

The levels measured during the period of this report contrast with the baseline levels in terms of lower apparent noise and lower peak values, both of which may be more indicative of improved instrumentation than any trend in background levels or source contributions.

Carbon Monoxide

During most of the period of this report, CO was monitored in conjunction with hydrocarbons using a gas chromatograph.

As a result of agency relief from the requirement to monitor hydrocarbons, the chromatograph was retired in August, 1978 and CO-specific instruments installed in Stations AB20 and AB23 . The data during September was taken with the new instrument. Although the data reduced at this time are insufficient to provide conclusive evidence, it is likely that less erratic CO levels will be observed at Station AB23 with the new instrument. No data for Station AB20 are included in this report, as the instrument in that station was brought on-line in late September, 1978.

Oxides Of Nitrogen, Nitrogen Dioxide

The observed concentrations of NO_x-NO_2 at Stations AB20 and AB23 follow a pattern similiar to the baseline data. The majority of the time levels exist at or below the lower detection limit of the instrument, with short-duration peaks up to 150 $\mu g/m^3$. This behavior correlates well with the expectations of a low regional background level influenced by intermittent contributions from various local combustion sources.

Ozone

The time plots of ozone are unique among the gaseous constituents in showing a distinct seasonal trend distinguishable from the data scatter. As expected, peak levels occur in midsummer, while lowest concentrations are observed in mid-winter, paralleling the variation in insolation. No significant trend is observable in the seasonal high levels over the entire monitoring history at Station AB23. Ozone concentration statistics are presented in Table 6.2.1-4.

The problem of causative factors related to high ozone levels in a rural area is a complex one, subject to the influence of many variables. This problem is treated in a separate Paragraph 6.2.1.4.6.

6.2.1.4.3 Comparisons of Maximum Concentrations With Ambient Air Standards

Table 6.2.1.-5 lists the maximum measured concentrations of gaseous constituents for averaging times corresponding to respective standards. In cases where values exceed the standard, all such values are listed. For the gaseous constituents, there have been no exceedances at the present standards, both State and Federal. A recent action of

TABLE 6.2.1-4

OXIDENTS (O_3) AT STATION AB23

(1975 - 1977)

```
                         OXIDENTS (O3)

                     FOR CALENDAR YEAR  1975

             C-b TRACT         RIO BLANCO COUNTY

                          TRAILER 023

Number Hourly Observations:              7160

Annual Arithmetic Mean (ug/m3):            69.0

5-Highest Hourly Averages (ug/m3):  1.  151.3   6/26    HOUR ENDING   1400
                                    2.  147.9   6/26      "     "     1500
                                    3.  142.4   2/23      "     "     2300
                                    4.  136.9   5/22      "     "     0300
                                    5.  136.9   5/22      "     "     0400

Number of Hourly Concentrations In Ranges:

       RANGE:                                   NO. OF VALUES:

     0.0  -     2.9  (ug/m3)                         3
     3.0  -    20.9                                 39
    21.0  -    40.9                               1160
    41.0  -    60.9                               1752
    61.0  -    80.9                               1385
    81.0  -   100.9                               2205
   101.0  -   120.9                                530
   121.0  -   140.9                                 83
   141.0  -   160.0                                  3
   GREATER THAN 160.0                                0
```

```
                         OXIDENTS (O3)

                     FOR CALENDAR YEAR  1976

             C-b TRACT         RIO BLANCO COUNTY

                          TRAILER 023

Number Hourly Observations:              8239

Annual Arithmetic Mean (ug/m3):            62.0

5-Highest Hourly Averages (ug/m3):  1.  124.0   4/26    HOUR ENDING   1500
                                    2.  123.0   4/26      "     "     1600
                                    3.  122.4   4/26      "     "     1700
                                    4.  120.3   4/26      "     "     1300
                                    5.  119.3   4/26      "     "     1400

Number of Hourly Concentrations In Ranges:

       RANGE:                                   NO. OF VALUES:

     0.0  -     2.9  (ug/m3)                        15
     3.0  -    20.9                                 50
    21.0  -    40.9                               1197
    41.0  -    60.9                               2611
    61.0  -    80.9                               2890
    81.0  -   100.9                               1232
   101.0  -   120.9                                241
   121.0  -   140.9                                  3
   141.0  -   160.0                                  0
   GREATER THAN 160.0                                0
```

```
                         OXIDENTS (O3)

                     FOR CALENDAR YEAR  1977

             C-b TRACT         RIO BLANCC COUNTY

                          TRAILER 023

Number Hourly Observations:              7874

Annual Arithmetic Mean (ug/m3):            79.0

5-Highest Hourly Averages (ug/m3):  1.  164.0   8/24    HOUR ENDING   1100
                                    2.  163.8   8/24      "     "     1200
                                    3.  162.6   8/24      "     "     1100
                                    4.  162.5   8/24      "     "     1000
                                    5.  158.1   7/31      "     "     0900

Number of Hourly Concentrations In Ranges:

       RANGE:                                   NO. OF VALUES:

     0.0  -     2.9  (ug/m3)                         2
     3.0  -    20.9                                  4
    21.0  -    40.9                                105
    41.0  -    60.9                               1232
    61.0  -    80.9                               3405
    81.0  -   100.9                               2066
   101.0  -   120.9                                842
   121.0  -   140.9                                179
   141.0  -   160.0                                 35
   GREATER THAN 160.0                                4
```

TABLE 6.2.1-5

COMPARISONS OF MAXIMUM BACKGROUND LEVELS WITH AMBIENT STANDARDS

APPLICABLE STANDARD	CONSTITUENT	AVERAGING TIME	STANDARD LIMIT ($\mu g/m^3$)	MAX. READING ($\mu g/m^3$)	DATA PRECISION ($\mu g/m^3$)	STATION WITH MAX. READING	DATE OF MAX. READING
COLORADO AMBIENT AIR QUALITY STANDARDS	PARTICULATES	ANNUAL	45*	14.5	0.6	023	1978
	PARTICULATES	24-HOUR	150**	178(1)	11	024	11/27/74(1)
				162(2)	10		11/29/74(2)
	H_2S	1-HOUR	142	72.2	8	023	12/22/74
NATIONAL AMBIENT AIR QUALITY STANDARDS							
PRIMARY	SO_2	ANNUAL	80	1.3	15	021 & 024	'74 - '75
		24-HOUR	365	43.1	15	021	6/16/75
SECONDARY	SO_2	3-HOUR	1300	87.7	15	023	12/21/74
PRIMARY	NO_2	ANNUAL	100	5.0	6	020	'75 - '76
PRIMARY	PARTICULATES	ANNUAL	75***	11.0	0.6	023	1978
		24-HOUR	260	178	11	024	11/27/74
SECONDARY	PARTICULATES	ANNUAL	60***	11.0	0.6	023	1978
		24-HOUR	150	178(1)	11	024	11/27/74(1)
				162(2)	10		11/29/74(2)
PRIMARY	CO	8-HOUR	10,000	4501.9	100	020	6/03/75
		1-HOUR	40,000	4650.9	100	020	6/04/75
PRIMARY	OXIDANT	1-HOUR	240	164.0(1)	20	023	8/24/77(1)
				163.8(2)	20	023	8/24/77(2)

* Proposed change to 75 $\mu g/m^3$ under consideration

** Proposed change to 260 $\mu g/m^3$ under consideration

*** Geometric mean

(1) Highest max. reading

(2) Second highest max. reading

the EPA revised the ozone standard upward from 0.08 to 0.12 ppm. The two cases of hourly-average values in excess of the old standard are well below the current one.

6.2.1.4.4 Correlations With Wind Direction and Speed

Sulfur gases, nitrogen oxides and carbon monoxide

Concentration roses, depicting variations in concentration with wind speed and direction are presented in Figures A6.2.1-5 thru -9. For the sulfur and nitrogen gases as well as carbon monoxide, there is no detectable dependence of concentration on either wind speed or direction. This result is easily understood in terms of the low levels of these constituents, which are more representative of regional background levels than of any specific source contributions.

Ozone

Plots of ozone concentrations vs. wind speed and direction are presented in Figure 6.2.1-3. The data are presented in this form since the levels of concentration monitored are typically more significant than the other gaseous constituents. Over the period of time depicted on the plots, it is difficult to reach any conclusion regarding wind dependency. Again, this is characteristic of regional background levels, not influenced to any significant degree by specific sources.

6.2.1.4.5 Special Study: Side-By-Side SO_2 Measurements

Scope & Rationale

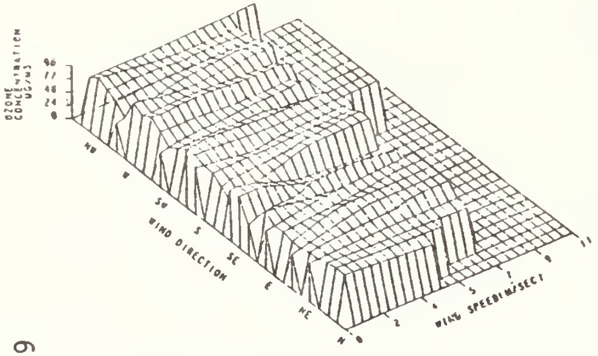
During the entire history of air monitoring at the C-b Tract, measured sulfur dioxide concentrations have averaged in the vicinity of the measurement threshold of the monitoring instruments, as shown in Figure B6.2.1-2. In order to validate the accuracy of the instruments in this range, and consequently qualify the resultant data, tests of co-located instruments have been made. Two tests were made: one over the period January through March, 1976 at Station AB21, and the other during April through July, 1977 at Station AB23. The earlier test was fully described in the Environmental Baseline Report.

Objectives

- to obtain a measure of agreement between co-located SO_2 analyzers
- to obtain an indication of the significance of air quality data for low concentrations of SO_2

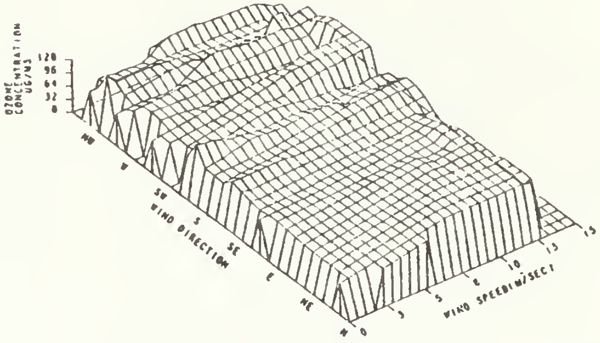
FIGURE 6.2.1-3

ONE HOUR OZONE CONCENTRATIONS AS FUNCTIONS OF WIND SPEED AND DIRECTION



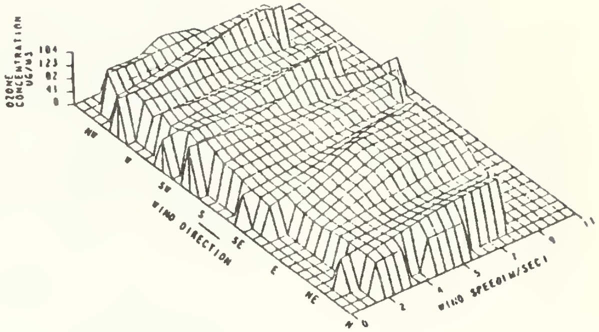
WIND SPEED-DIRECTION VS CONCENTRATION

STATION AB23 DEC '76-FEB '77



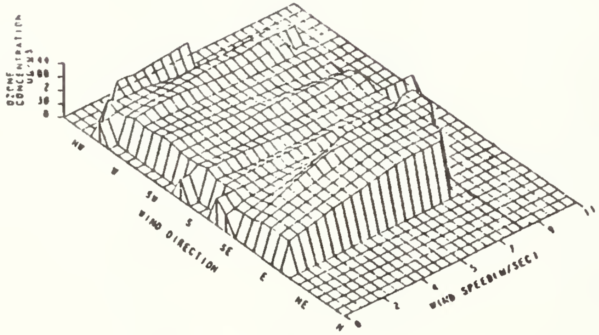
WIND SPEED-DIRECTION VS CONCENTRATION

STATION AB23 MAR '77-MAY '77



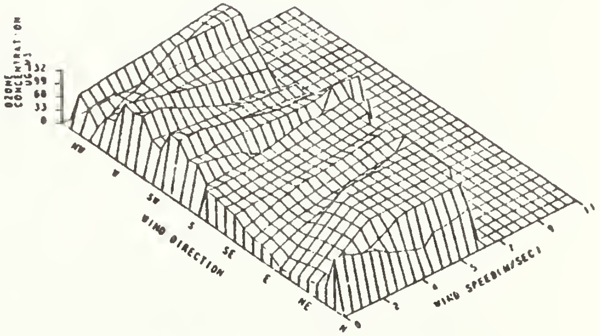
WIND SPEED-DIRECTION VS CONCENTRATION

STATION AB23 JUNE '77-AUG '77



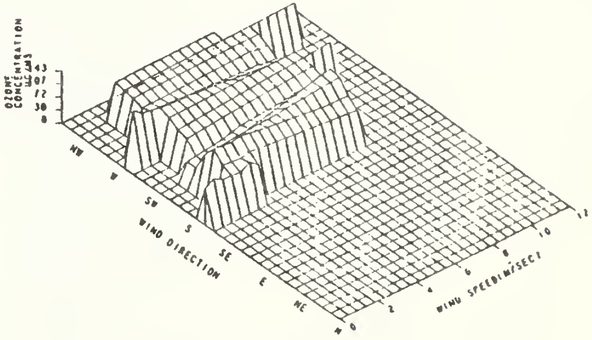
WIND SPEED-DIRECTION VS CONCENTRATION

STATION AB23 SEPT '77-NOV '77



WIND SPEED-DIRECTION VS CONCENTRATION

STATION AB23 DEC '77-FEB '78



WIND SPEED-DIRECTION VS CONCENTRATION

STATION AB23 MAR '78-APR '78

Experimental Design

Two Meloy sulfur dioxide analyzers, one model SA-185-2 and one model SA-185-2A were operated at Station AB23. The two analyzers were connected to the same air intake manifold and the same hydrogen supply. The significant difference between the two analyzers is in the minimum detection limit: 5-PPB for the SA-185-2 and 2 PPB for the SA-185-2A.

Method of Analysis

The data sets for each analyzer were reduced to diurnal tables of hourly averages. These tables were then compared to produce diurnal tables of hourly average difference between analyzer outputs. Maximum and mean hourly difference, and the standard deviation of hourly average differences were computed for each month. Prior to and during the test period, both analyzers were calibrated in an identical manner.

Results and Discussion

Diurnal tables of hourly differences are presented in Tables A6.2.1-3a to d. The results of the above described analyses are presented in Table 6.2.1-6. For each month, the monthly average output of the SA-185-2A monitor never exceeded the minimum detection limit, while the SA-185-2 indicated outputs in excess of its detection limit an average of 10.6% of the four-month period. The average output for the SA-185-2 was 0.9 $\mu g/m^3$ (0.3 PPB). This discrepancy in output might seem contrary to the minimum detection limit specifications for the analyzers, which indicate that the SA-185-2A is the more sensitive instrument. However, the SA-185-2A was a new instrument at the time of the side-by-side tests, and also is made to qualify for EPA certification as a reference method. It is therefore reasonable to expect less drift and lower noise in the SA-185-2A. The combination of noise and drift between calibrations would account for the SA-185-2 indicating a low level of concentration when the new analyzer registered zero.

That most of the significant hourly differences between analyzers was random is demonstrated by the extremely low values for mean hourly difference. The maximum value of this mean, 1.0 $\mu g/m^3$ or 0.38 PPB, is well within the acceptable noise level for either analyzer. (Instrument specifications can be found in Table A.6.2.1-1.

Conclusions

1) During the four months of side-by-side tests no significant difference between analyzers was found.

2) The performance of the new SA-185-2A analyzer was established as a satisfactory replacement to the SA-185-2.

3) Between the two analyzers, outputs above threshold detection occurred only 10.6% of the time, with monthly average levels of no more than 1.6 $\mu g/m^3$ (0.6 PPB). The results for both analyzers demonstrate that the background level of SO_2 is extremely low.

TABLE 6.2.1-6 SUMMARY OF RESULTS OF SIDE-BY-SIDE
SO_2 ANALYZER TEST ($\mu g/m^3$)
1977

Item	Analyzer								Difference Between Analyzers			
	#1 Meloy SA 185-2A				#2 Meloy SA 185-2							
	April	May	June	July	April	May	June	July	April	May	June	July
Monthly average (rounded)	0	0	0	0	0	1.6	1.0	1.0				
% hours above detection limit	0	0	0	0	0	1.0	24.5	17.0				
Total no. paired observation									709	736	676	662
Total no. non-zero differences									91	152	169	124
Mean hourly difference									0.3	0.5	1.0	0.47
Std. dev. of hourly difference									1.3	1.5	3.1	1.49
Maximum hourly difference									15	10	32	17

4) The standard deviation of the hourly differences for each month exceeds the corresponding monthly average by at least a factor of three, indicating that the actual analyzer output values are of little significance when measuring extremely low concentrations.

6.2.1.4.6 Special Study: Interrelationships of Ozone with Ambient Meteorological Parameters

Scope and Rationale

This is a study of the interrelationships of ozone with ambient air quality parameters. It is based on hourly averages of continuous measurements of ozone, solar radiation, temperature, relative humidity, barometric pressure, wind speed, and wind direction for the month of August, 1977.

Objective

To evaluate the interrelationships of several meteorological parameters on ozone concentrations in search of a weather-related explanation of significant shifts in diurnal ozone concentration levels.

Experimental Design

August, 1977 diurnal tables of hourly averages of continuous observations of ozone, solar radiation, temperature, relative humidity, barometric pressure, wind speed, and wind direction form this data base. Statistical analyses utilizing correlation, partical correlation, multiple regression, univariate time series, and multiple time series transfer functions were performed and evaluated comparatively. Time series analysis was used to develop forecast models with confidence intervals of ozone concentration. Forecasts of ozone concentration are compared with actual observations through periods of ozone-level shift.

Time series consisting of hourly values were plotted for each of the parameters. Ozone series was examined to identify time periods representing normal, low, transition, and high levels of concentrations. These periods were examined for interrelationships between ozone and meteorological parameters utilizing computer programs for correlation and multiple linear regression. Outputs of the computer programs provide analyses for evaluating statistical significance of interrelationships and value of these for predicting shifts in levels of concentration for ozone. (Bullard and Fosdick, 1979)

Results and Discussion

The primary data used for the study are the hourly measurements of ozone, solar radiation, temperature, relative humidity, barametric pressure, wind speed, and wind direction for the month of August 1977. Since these data were analyzed as time series, they are presented here as a composite of computer plots of the individual diurnal series in Figure 6.2.1-4 with ozone in the center of the figure. The parameters were plotted by hour; days of the month are indicated. Vorticity data derived for the 500 mb pressure level were also used in the analysis and plotted as an overlay on the ozone plot.

Of interest in this study were shifts in the ozone level from a "normal" to "low" and then to "high", as indicated on Figure 6.2.1-5.

Day 23 was designated as "transition" day since the ozone level appeared to shift from the "low" to "high" level on that day. The "normal" period is extended through day 17 in later time series analyses.

The shifts between the levels of ozone as measured by the means and standard deviations were significant. Daytime highs and nighttime lows also shifted indicating that the diurnal patterns themselves completely shifted levels.

TABLE 6.2.1-7

SIMPLE CROSS CORRELATION MATRIX

		OZONE	SOLAR RADIATION	TEMP.	RH	PRESS	WS
OZONE	N	1.00					
	L	1.00					
	T	1.00					
	H	1.00					
SOLAR RADIATION	N	.52	1.00				
	L	.49	1.00				
	T	.37	1.00				
	H	.18	1.00				
TEMPERATURE	N	.80	.67	1.00			
	L	.86	.66	1.00			
	T	- .36	.66	1.00			
	H	.55	.69	1.00			
RELATIVE HUMIDITY	N	- .75	- .36	- .69	1.00		
	L	- .82	- .58	- .95	1.00		
	T	- .55	- .81	- .48	1.00		
	H	- .40	- .49	- .82	1.00		
BAROMETRIC PRESSURE	N	- .29	.13	- .31	.46	1.00	
	L	- .33	- .05	- .43	.53	1.00	
	T	.37	- .07	- .13	- .96	1.00	
	H	.52	- .22	- .06	.36	1.00	
WIND SPEED	N	.46	.37	.66	- .34	- .26	1.00
	L	.66	.67	.78	- .89	- .36	1.00
	T	-	.52	.86	- .70	- .13	1.00
	H	.11	.54	.55	- .62	- .65	1.00

NOTE: Normal, Low, Transition, and High ozone periods are designated by N, L, T, and H respectively. Correlation coefficients greater than .50 are significant at the .99 confidence level.

Coefficients of correlation were then examined to test the hypothesis that the interrelationships among the parameters remain unchanged for each of the ozone levels. Table 6.2.1-7 shows the matrix of the simple cross correlations without time lags. As might be expected, high correlation coefficients are indicated reflecting the significant diurnal effect on each of the parameters. Coefficients above 0.50 are significant at the 99 percent confidence level for the sample sizes.

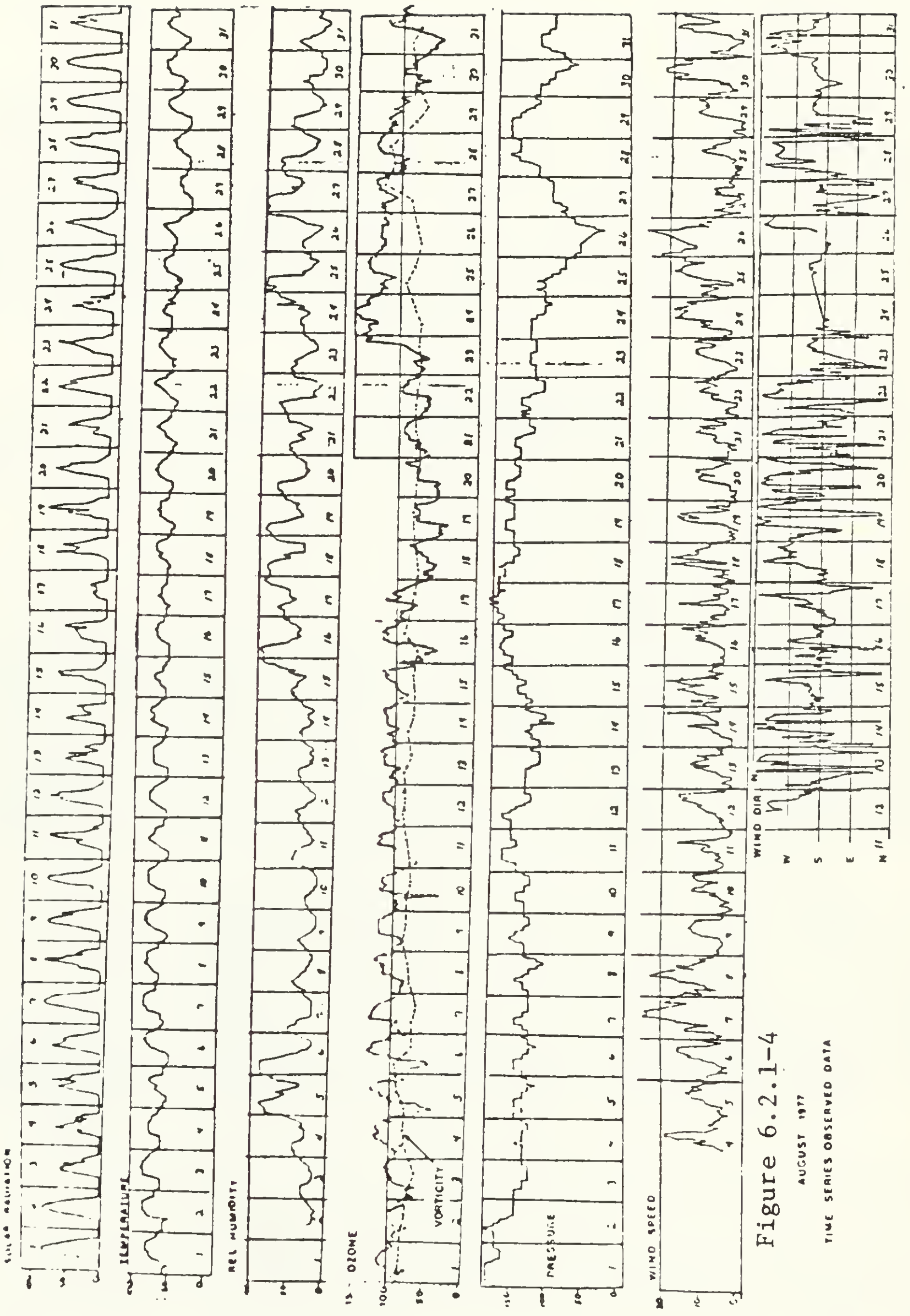
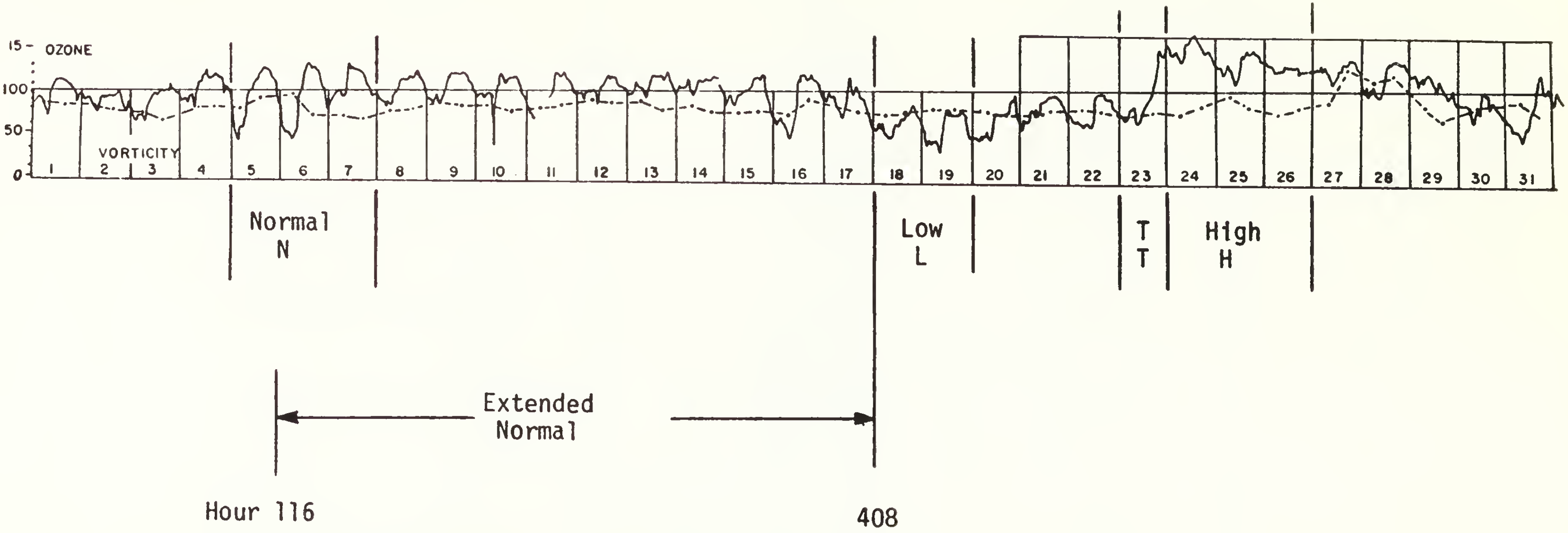


Figure 6.2.1-4

AUGUST 1977

TIME SERIES OBSERVED DATA

Figure 6.2.1-5 OZONE STUDY LEVELS AND ASSOCIATED STATISTICS



STATISTICS

Period	Ozone Level	Mean	Standard Deviation	Daytime High	Night-time Low	Significant Shift?
Aug 5-7	Normal	95.8	26.6	130(ug/m^3)	43(ug/m^3)	Ref. mean
Aug 18-19	Low	57.4	12.6	81	28	Yes
Aug 23	Transition	100.1	34.6	152	62	Yes
Aug 24-26	High	134.6	12.8	163	109	Yes
Aug 6-17	Ext. Norm.	96.1	18.3	129	31	---

Relative changes in coefficient levels and/or sign indicate the following with respect to interrelationships of ozone to other parameters:

between N and L = little change in sign of values of coefficients
between N and H = significant change in sign of values of all coefficients
between L and H = significant change in sign or values of all coefficients

Indications are that the "high" ozone level has different interrelationships with the meteorological parameters than exists for "normal" and "low" ozone levels.

Multiple linear regression analyses were performed in order to obtain the predictive relationship between ozone and a set of observations of meteorological parameters. The general form of the linear regression equation for estimating ozone (O_3) from a set of observations of the related parameters is:

$$\hat{O}_3 = B_o+C_1SR+C_2T+C_3RH+C_4P+C_5WS$$

where

$\hat{O}_3$ is ozone estimated value.
B_o is an offset constant for parameter levels called the intercept.
C_1, C_2, ...C_5 are regression coefficients for the respective parameters in the observed set.
SR = solar radiation (langleys)
T = temperature (°C)
RH = relative humidity (%)
P = pressure (mb)
WS = wind speed (m/s)

Table 6.2.1-8 shows the regression coefficients for the selected ozone level periods:

TABLE 6.2.1-8
REGRESSION EQUATION COEFFICIENTS

Level	Bo Inter-cept	C_1 SR	C_2 T	C_3 RH	C_4 P	C_5 WS	Multiple Correlation Coefficient
Normal	- 964.8	.266	.385	-.587	-1.68	-.777	.97
Low	-1802	-.101	1.09	-.250	2.28	.185	.88
Transition	-13089	-1.02	.383	-2.29	16.76	.824	.93
High	-3679	-.091	.120	-.332	4.83	1.17	.89
Norm Est	-491.3	-.005	1.11	-.36	.66	-.91	.85

Note that B_0, the intercept, is highly dependent on C_4, the pressure coefficient. This is because pressure has a mean value of about 790 mb, order of magnitude higher than any other parameter. Pressure change is a precursor of weather fronts which may be associated with ozone shift. Temperature and relative humidity are highly negatively correlated and one could be dropped from the set of estimating parameters. However, the combined contribution of temperature and relative humidity are significant in the estimating equation.

Comparison of regression coefficients across the ozone levels show that, for the transition period, solar radiation, relative humidity, and pressure coefficients, exhibit the greatest change from their previous level. Pressure influenced ozone levels in the transition phase. The meteorological parameter interrelationships with ozone change during the transition period. This change appears to be storm front related.

The high multiple correlation coefficients indicate high predictive confidence in the regression equation over the time periods.

Conclusions

The analysis presented in this section demonstrates that significant correlations exist between shift in ozone levels and changes in measurable meteorological parameters. These correlations tend to indicate a natural mechanism for observed increases above background ozone levels. However, before details of such a mechanism may be elucidated, additional data possibly including parameters such as vorticity must be undertaken.

6.2.2 Particulates

6.2.2.1 Scope and Rationale

Monitoring of ambient particulates is required by the Oil Shale Lease Stipulations and by Federal and State Air Quality Regulations. Measurements were made on a daily basis through August 1977 and on an every-third day schedule at Station AB23 from September 1977 through September 1978 and continue on that basis. Additional particulate monitoring was initiated in February 1978 at Stations AB20, AD42, and AD56 on the same three-day sampling schedule. During visibility measurement days, size-distributed samples have been taken at Station AB23.

6.2.2.2 Objectives

- to demonstrate compliance with applicable regulations
- to examine potential long-term trends
- to provide a general air quality status assessment
- to identify potential particulate sources

6.2.2.3 Experimental Design

The EPA reference method for particulate monitoring, the hi-volume sampler, is employed at all stations to measure particulates. The samplers are located such that the air intakes are approximately 4.6 meters above ground level. An Anderson particle-sizing head is used in place of the standard filter assembly for size-distributed samples. As yet, there is no EPA reference method for particle size sampling.

6.2.2.4 Method of Analysis

The data on ambient particulates were not subjected to any formal analysis that resulted in usable information. Multiple regression analysis utilizing a technique and set of correlative parameters similar to those used in the visibility analysis failed to produce any valid correlations.

Three dimensional and time-series plots of particulate data provide a means of interpreting the data in a qualitative way. These are discussed in the following subsections.

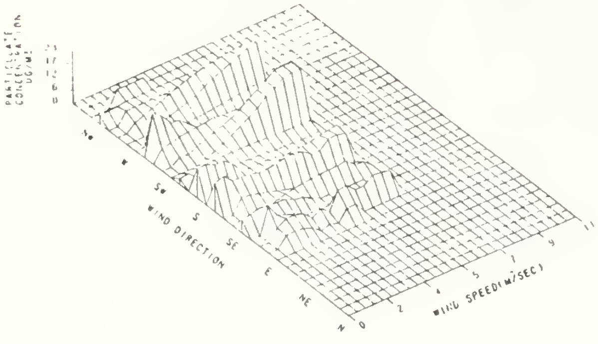
6.2.2.5 Results and Discussion

6.2.2.5.1 Correlation With Wind Direction and Speed

Plots of particulate concentration vs. wind speed and direction for Station AB23 are presented in Figure 6.2.2-1. In general, the data show a marked dependency on wind speed, as would be expected in a situation where particulate concentrations are primarily the result of fugitive sources. This factor is most evident during the spring and summer quarters. During the rest of a typical year, substantial periods of snow cover reduce the background level and change this relationship.

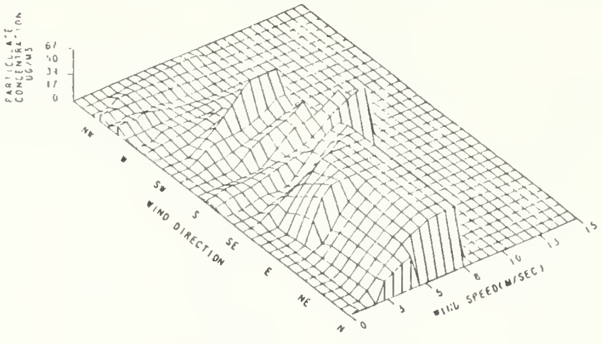
FIGURE 6.2.2-1

DAILY TOTAL PARTICULATE CONCENTRATIONS AS FUNCTIONS OF WIND SPEED AND DIRECTION



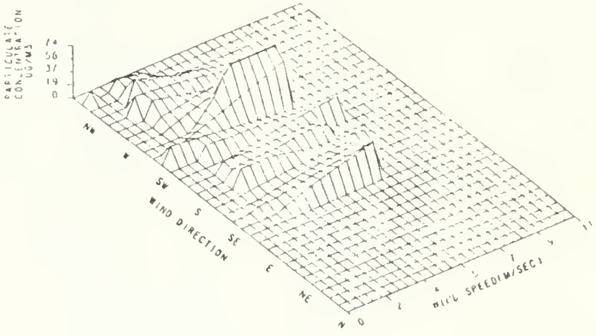
WIND SPEED-DIRECTION VS CONCENTRATION

STATION AB23 DEC '76-FEB '77



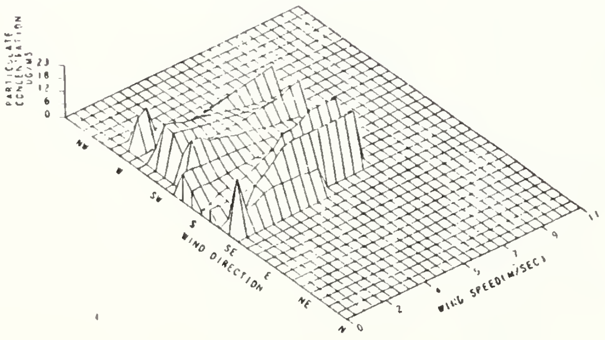
WIND SPEED-DIRECTION VS CONCENTRATION

STATION AB23 MAR '77-MAY '77



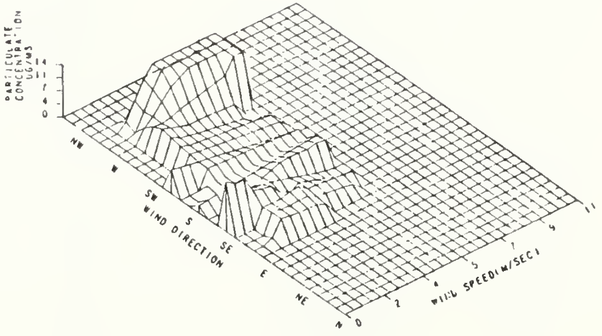
WIND SPEED-DIRECTION VS CONCENTRATION

STATION AB23 JUNE '77-AUG '77



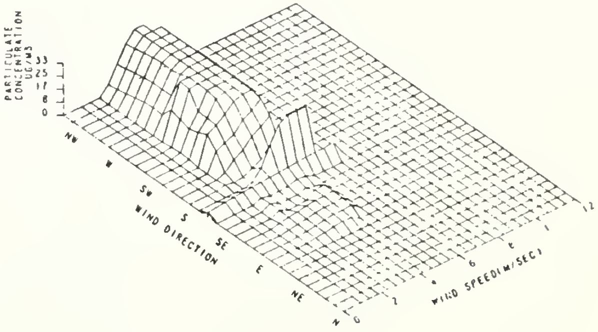
WIND SPEED-DIRECTION VS CONCENTRATION

STATION AB23 SEPT '77-NOV '77



WIND SPEED-DIRECTION VS CONCENTRATION

STATION AB23 DEC '77-FEB '78



WIND SPEED-DIRECTION VS CONCENTRATION

STATION AB23 MAR '78-MAY '78

Particulates generated then on or near the Tract will show a much smaller dependence on wind speed, sometimes actually resulting in higher concentrations at lower wind speed. These source-specific contributions become less significant compared to background levels during the spring-summer period.

There is no definite wind direction dependence indicated. The virtual absence of particulate measurements in the wind sector centered around the north-northeast direction is indicative of the low incidence of winds from that sector. Since particulate measurements are discrete 24-hour samples, the direction used for a particular sample is the average wind direction during that 24-hour period.

6.2.2.5.2 Concentrations As Time Histories

The time series plot of particulate concentrations for Station AB23 (Figure B6.2.2-2) is used for this discussion, as it is the only continuous record covering the complete history of air monitoring at the C-b Tract.

The one dominant feature of the plot is the seasonal variation. Maximum levels typically occur in the spring and fall, minimum levels in the winter. Concentrations during the summer months are variable from year to year, but are lower than the spring and fall peaks in most cases.

Histograms depicting the frequency distributions of particulate concentrations (Figures 6.2.2-2 and -3) show the predominance of low concentrations. The composite histogram displays a skewed log-normal distribution, typical of particulate concentrations influenced mainly by random variation in meteorological parameters.

6.2.2.5.3 Maximum Concentrations Compared with Ambient Standards

Table 6.2.1-5 lists the maximum annual and 24-hour particulate concentrations. Comparing these to ambient standards is complicated by the number of standards currently existing.

The Federal Primary Standards have not been exceeded at any time. On a 24-hour basis, the maximum value is 178 $\mu g/m^3$ compared to the proposed standard of 260. A wider margin exists on an annual basis. The 24-hour maximum, however, exceeds the Federal Secondary Standard, which is identical to the Colorado Standard, 150 $\mu g/m^3$. Neither the Federal Secondary Annual Standard of 60 $\mu g/m^3$ nor the State Annual Standard 45 $\mu g/m^3$ is approached.

Colorado has recently proposed a revision of their particulate standards to parallel the Federal Primary Standards. This action would bring all particulate data below all standards except the Federal Secondary 24-hour.

Attention is called to the fact that in the Environmental Baseline Summary Report peak particulate levels are attributed to fugitive dust for the time period exceedances were obtained.

FIGURE 6.2.2-2
FREQUENCY DISTRIBUTION OF PARTICULATE
MEASUREMENTS
BY YEAR

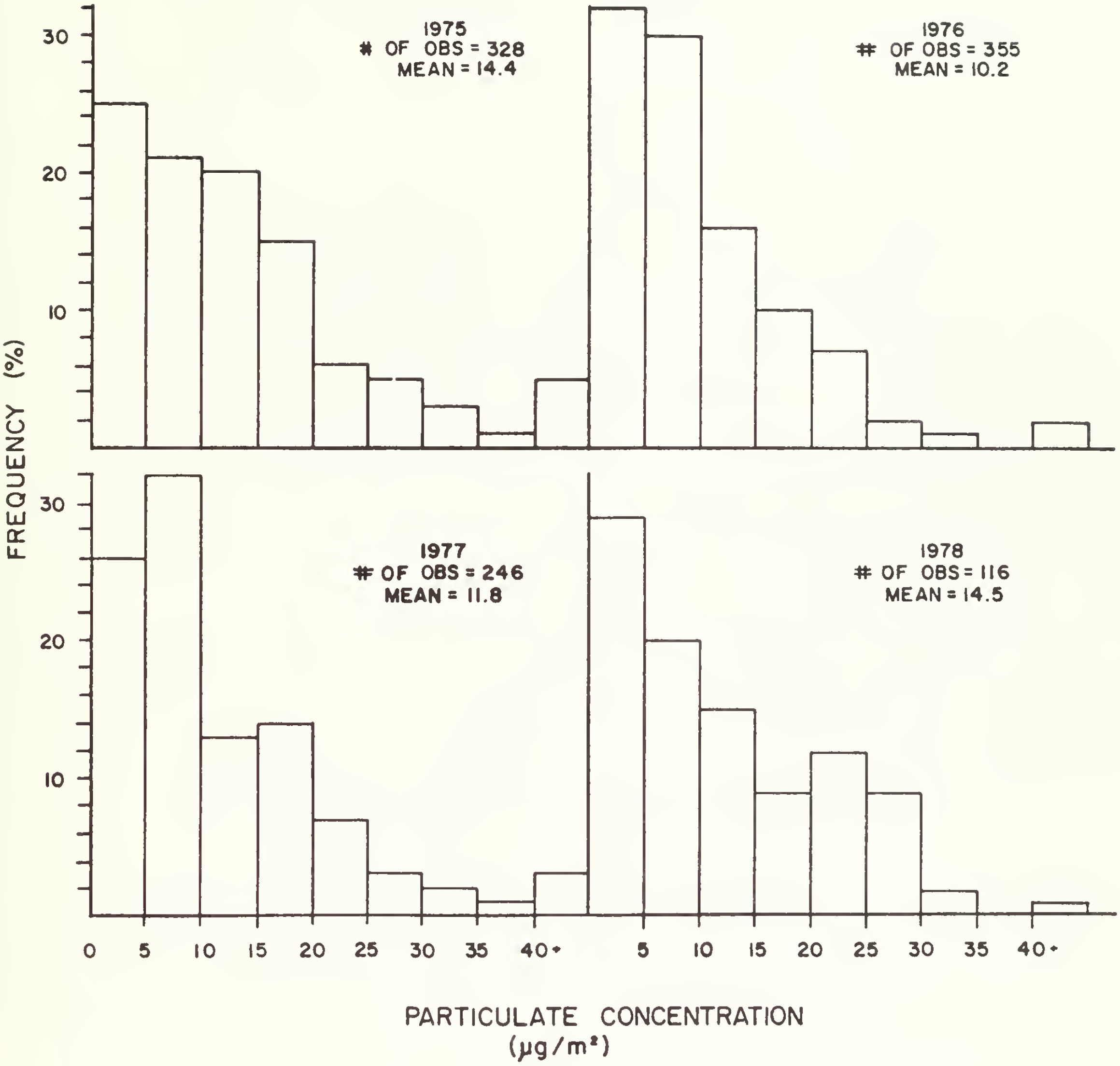
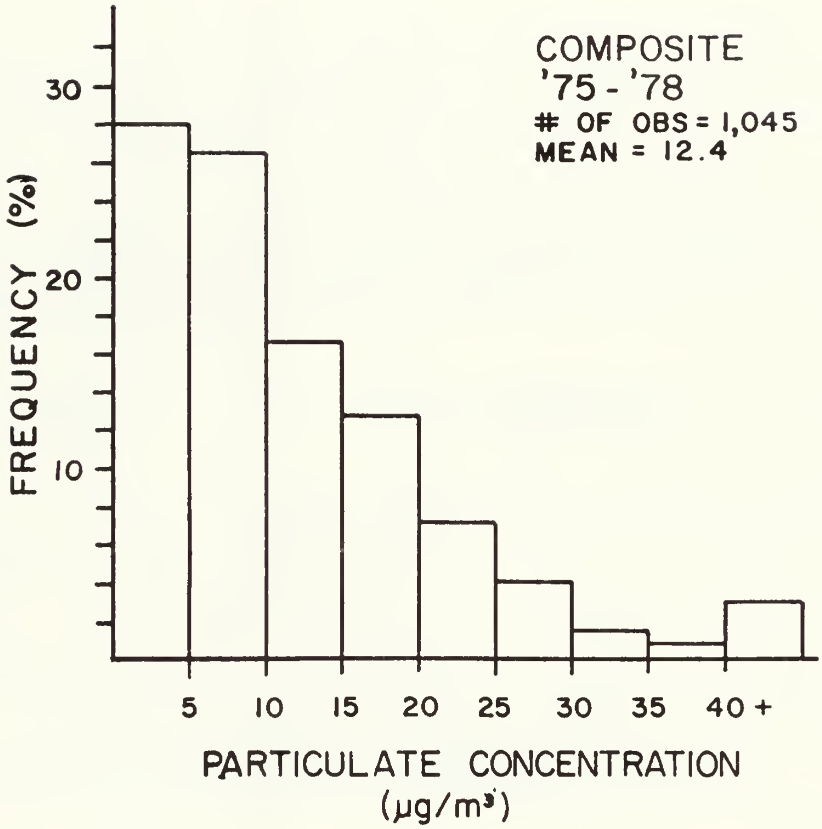


FIGURE 6.2.2-3
COMPOSITE PARTICULATE FREQUENCY DISTRIBUTION



6.2.2.6 Conclusions

1. Particulates in the area of the C-b Tract are primarily rural in origin, particularly those responsible for maximum concentrations.

2. Although firm correlations have yet to be drawn, seasonal trends in particulate concentrations suggest a general meteorological dependence.

3. No long-term trend over time is evident in the particulate data taken through September, 1978.

6.2.3 Visibility

6.2.3.1 Scope and Rationale

The visibility monitoring program has been co-sponsored by the C-b and Rio Blanco Shale Oil Projects. Measurements were taken every sixth day for a total of ten days in the Spring quarter, 1978, and ten days in the Fall. There are no state or federal requirements for visibility monitoring, however, the program is required under the Federal Oil Shale Lease Environmental Stipulations.

6.2.3.2 Objectives

- to establish baseline visibility levels for the Piceance Basin
- to identify any trends in visibility
- to establish correlations between visibility and meteorological and/or air quality parameters.

6.2.3.3 Experimental Design

Visibility data were obtained by means of photographs taken from an observation site approximately eight miles southwest of Piceance Creek on a ridge between Hunter Creek and Dry Gulch. This site was chosen for its proximity to the C-a and C-b Tracts, as well as for its accessability and range of views.

Photographs were taken at hourly intervals throughout the measurement days in each of four views. (See Figure 6.2.3-1). The use of at least two objects in each view enabled the measurement of visual range under a variety of visibility conditions. The locations of the observation site and objects are shown on the Figure.

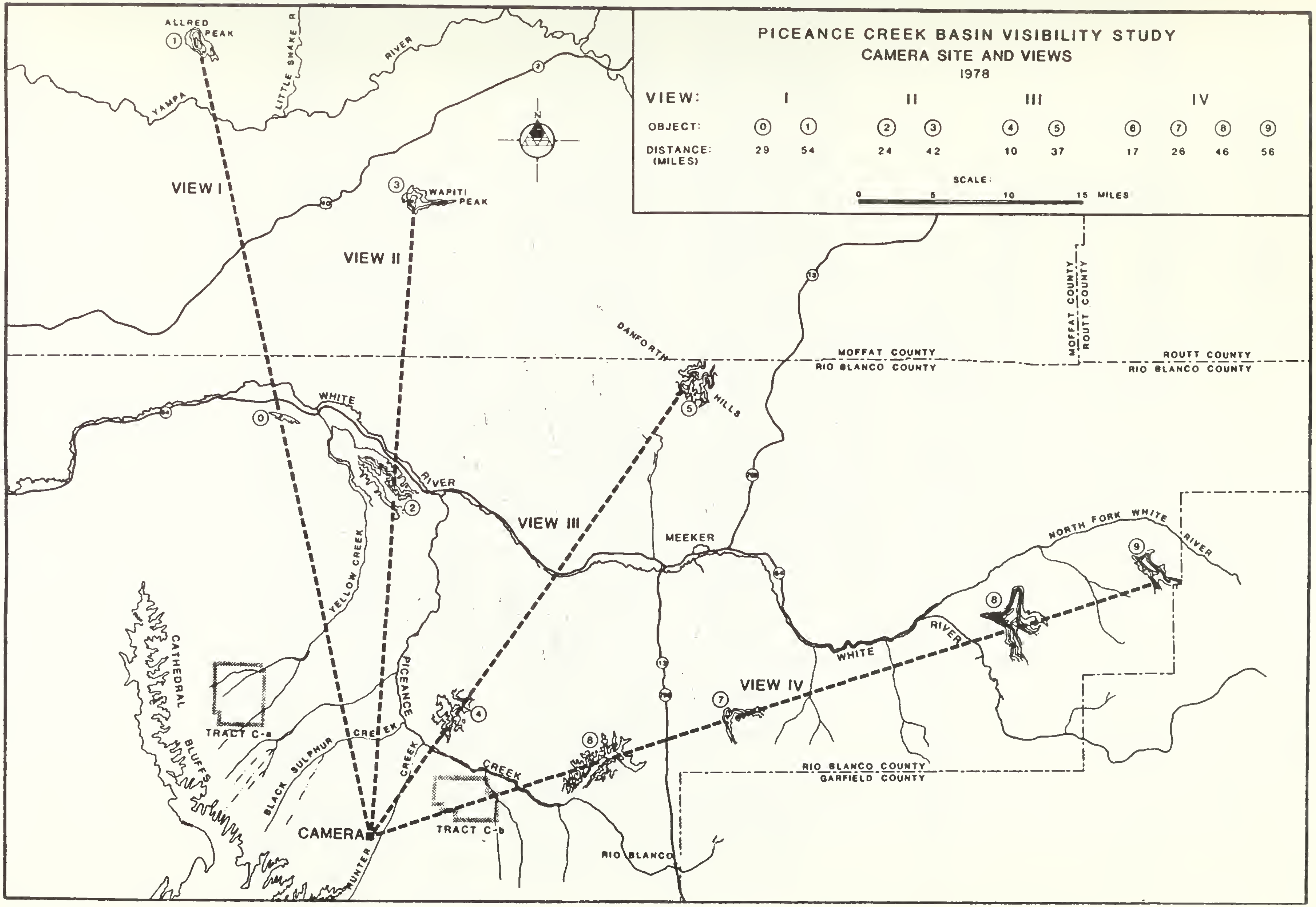
Visual range information is extracted from the photographs by means of optical density measurements on the portions of the photograph representing a given object and the horizon sky directly above it. These densities, together with the actual object-camera distance and the object albedo are used to calculate a visual range.

6.2.3.4 Methods of Analysis

In that there has been only one year of seasonal visibility measurements since the baseline visibility study of 1975-1976, there is no basis for analysis of long term trends in visibility. Visual range results have been compiled and averaged on a per-view and composite basis over monthly, seasonal, and annual periods to facilitate comparison with baseline data.

There has been analysis of a different kind applied to the 1978 visibility

FIG. 6.2.3-1



PICEANCE CREEK BASIN VISIBILITY STUDY
CAMERA SITE AND VIEWS
1978

VIEW:	I		II		III		IV			
OBJECT:	⓪	①	②	③	④	⑤	⑥	⑦	⑧	⑨
DISTANCE: (MILES)	29	54	24	42	10	37	17	26	46	56

data, utilizing the results of the correlation and regression analysis for visual range presented in the Enviromental Baseline Report. These results are presented in summary form in Table 6.2.3-1.

The multiple regression coefficients and intercept values from the table were used with meteorological data from visibility measurement days to compute an estimated visual range, according to the formula

$$Yest= b_o+ \Sigma_i (b_i x_i)$$

b_o = intercept
b_i = regression coefficient, ith variable
x = value of ith primary variable
i = 1 to 8 primary variables
For the case presented, all eight primary variables were used.

6.2.3.5 Results and Discussion

The results of the 1978 visibility monitoring program, compared, where appropriate, with baseline results, are presented in Figures 6.2.3-2 through 6.2.3-5. The daily variation in mean visual range is depicted in Figure 6.2.3-2. These time plots indicate the sharp drops in mean visual which accompanied weather changes during early May and late November. Descriptions of general weather conditions are contained in the Site Log Sheets presented in Appendix A6.2.3.

The monthly composite visual range distributions, Figure 6.2.3-3, show shifts both up and down scale from the baseline data. Additional years of data will be required before any trend could be detected. The annual composite distributions shown in Figure 6.2.3-4 indicate a high degree of overall comparability between 1975-76 and 1978. The composites for each view appear to have a stronger central tendency for '78 than for '75-'76, which would be indicative of fewer extremes in meteorological parameters.

No explanation has been found for the low frequency of visual range in the 60-69 mile range which was found in both data sets.

Results of the multiple regression analysis are presented in Table 6.2.3-2. In general the error of the estimated visual range was too large for this technique to be of value in predicting a daily mean visual range from a set of meteorological parameters. However, a comparison of the mean values shows a good approximation of the means of the measured values. Thus the computation method may prove to be useful in assessing the validity of future visibility monitoring, as the data base for regression become larger.

Table 6.2.3-1

SUMMARY OF VISUAL RANGE CORRELATION AND REGRESSION ANALYSES

FROM ENVIRONMENTAL BASELINE REPORT, VOLUME 3

Parameter	Sym	Units	Mean	Std Dev.	Coef. Corr.	Multiple Regression Coefficients Primary Variables								Multiple Regression Coef. Primary and Secondary Var.					
1. Particulates	PA	$\mu g/m^3$	11.7	12.5	-.125	-.196	-.209	-.213	-.204	---	---	---	---	-.184	-.189	-.197	-.220	---	---
2. Wind Speed-30'	WS	mph	6.92	3.35	-.072	2.79	2.84	2.84	2.81	2.83	---	---	---	15.1	14.9	---	---	---	---
3. Solar Radiation	SR	langleys	364.	182.	.118	-.002	-.002	---	---	---	---	---	---	-.014	-.014	-.004	---	---	---
4. Ozone	OZ	$\mu g/m^3$	54.4	17.6	-.111	-.261	-.258	-.266	-.236	-.264	-.340	-.409	---	-.141	-.141	-.233	-.247	---	---
5. Rel. Humidity	RH	%	52.7	17.6	-.560	-.809	-.819	-.815	-.834	-.819	-.837	-.829	-.694	-.819	-.822	-.810	-.812	-.738	-.722
6. Temperature	TP	^oF	44.0	17.4	.114	.070	.068	.062	---	---	---	---	---	.155	.155	.063	.047	---	---
7. Precipitation	PP	in.	.021	.078	-.304	-6.42	---	---	---	---	---	---	---	-1.73	---	-6.85	---	---	---
8. Max. Wind Speed	MW	mph	17.7	6.64	-.179	-1.80	-1.83	-1.82	-1.80	-1.07	-.607	---	---	-6.72	-6.61	---	---	---	---
9. (Wind Speed)^2		(mph)^2	58.6	56.7	-.022	---	---	---	---	---	---	---	---	-1.88	-1.84	-.184	.185	.260	---
10. (Wind Speed)^3		(mph)^3	586.	847.	.031	---	---	---	---	---	---	---	---	.080	.079	---	---	---	---
11. (Max. Wind Speed)^2		(mph)^2	356.	257.	-.145	---	---	---	---	---	---	---	---	.080	.079	-.046	-.046	-.070	-.018
12. (Max. Wind Speed)^3		(mph)^3	7960.	8304.	-.103	---	---	---	---	---	---	---	---	-.003	-.002	---	---	---	---
13. Visual Range	VR	mi.	76.1	21.8	---	DEP	DEP	DEP	DEP	DEP	DEP	DEP	DEP	DEP	DEP	DEP	DEP	DEP	DEP
Intercept (m)						146.	146.	146.	148.	149.	149.	142.	113.	152.	152.	138.	138.	125.	120.
Multiple Correlation Coefficient						.694	.694	.694	.692	.686	.665	.642	.560	.740	.740	.692	.692	.662	.598
Standard Error of Estimate (mi).						16.8	16.7	16.5	16.4	16.4	16.7	17.0	18.2	16.4	16.2	16.9	16.6	16.8	17.8

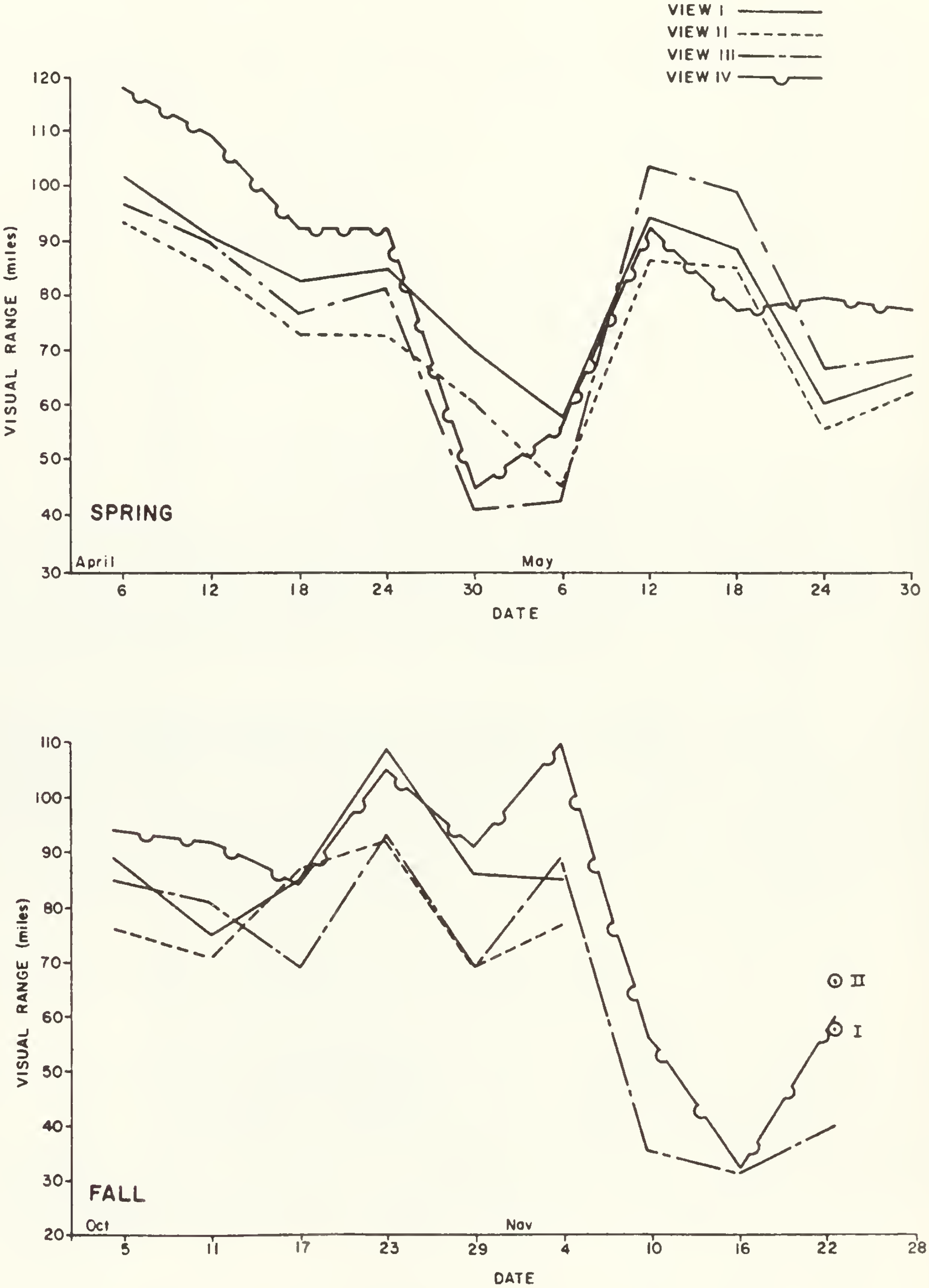


FIGURE 6.2.3-2

VARIATION IN DAILY MEAN VISUAL RANGE FOR EACH VIEW
PICEANCE CREEK BASIN, COLORADO
SPRING and FALL, 1978

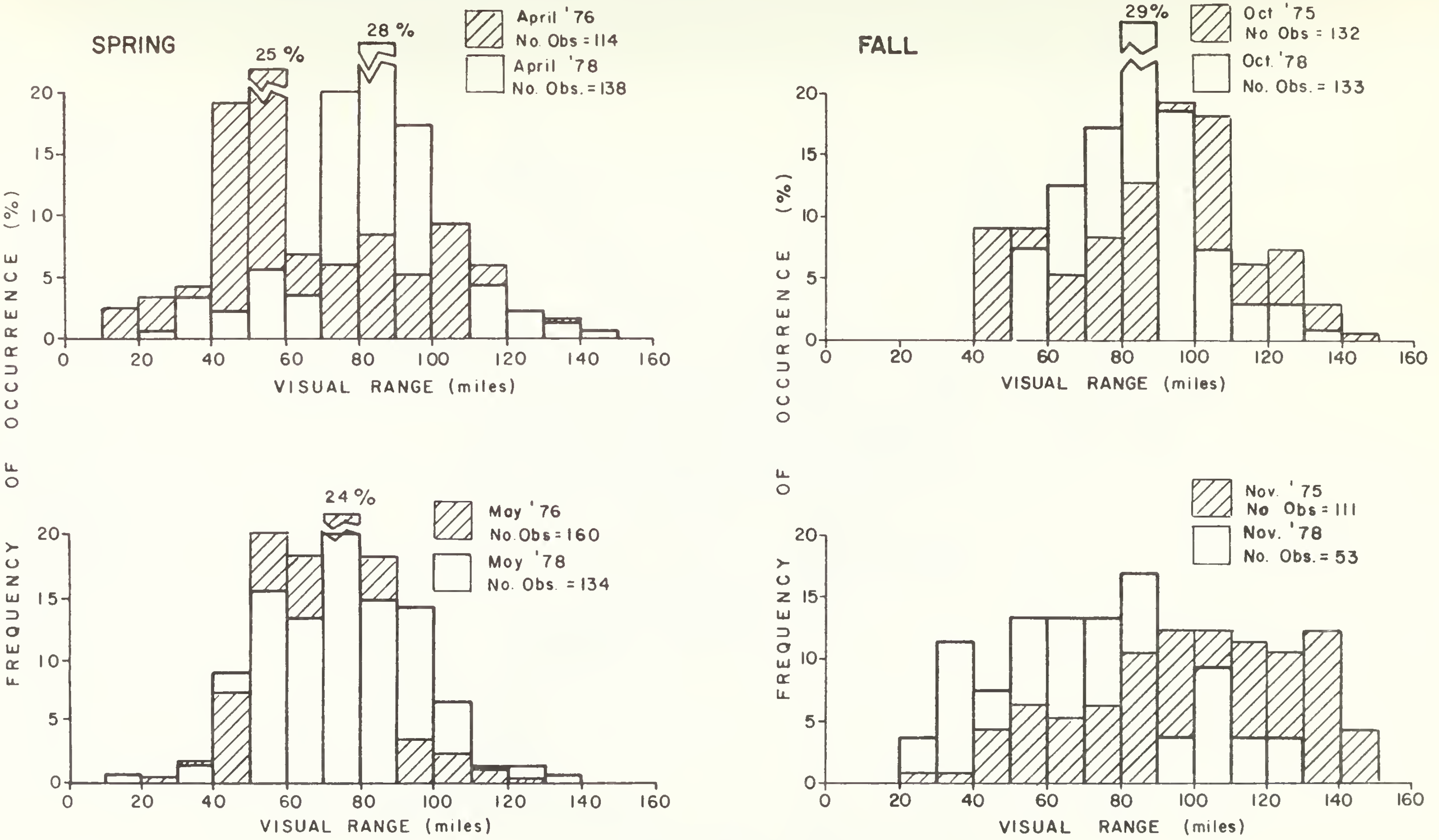


FIGURE 6.2.3-3
MONTHLY COMPOSITE DISTRIBUTION OF VISUAL RANGE
PICEANCE CREEK BASIN, COLORADO
SPRING and FALL, 1978

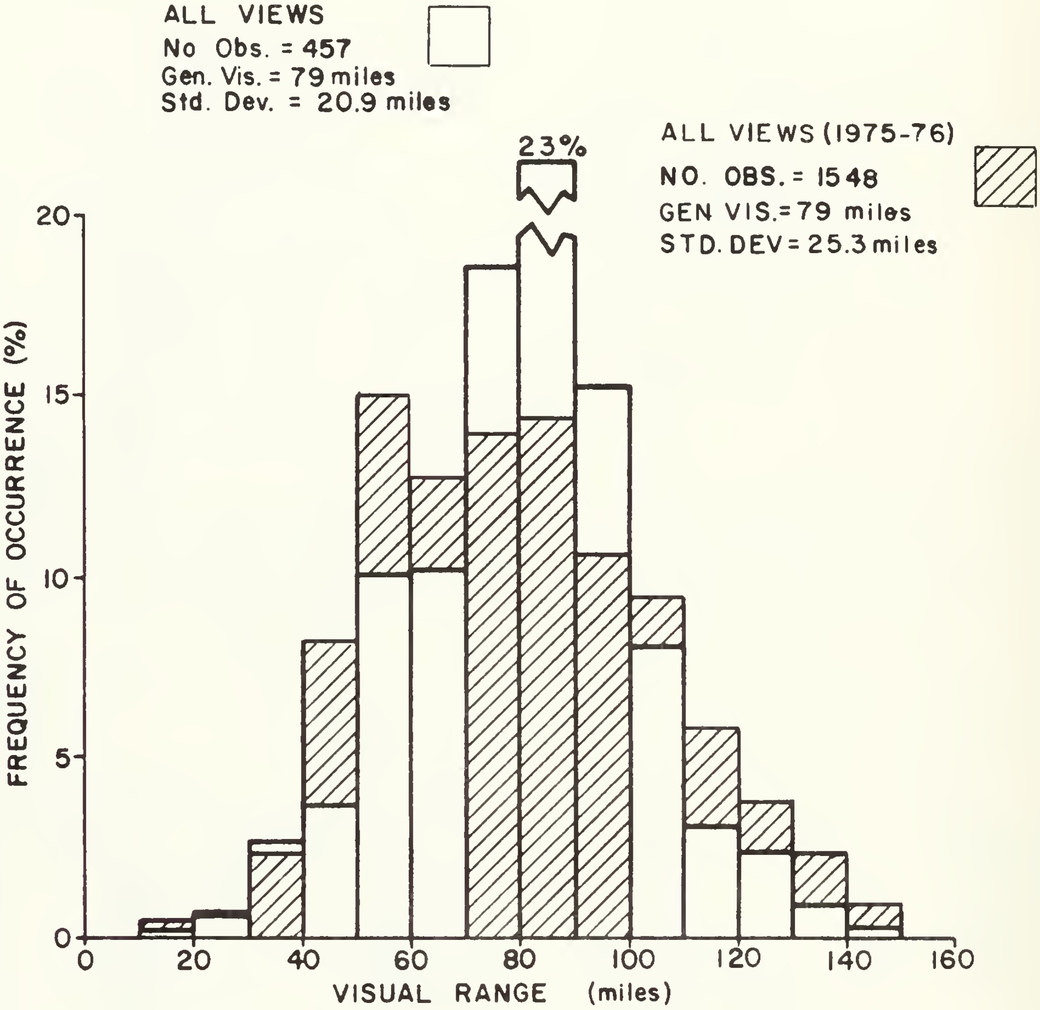


FIGURE 6.2.3-4
ANNUAL COMPOSITE DISTRIBUTION OF VISUAL RANGE
PICEANCE CREEK BASIN, COLORADO
SPRING and FALL, 1978

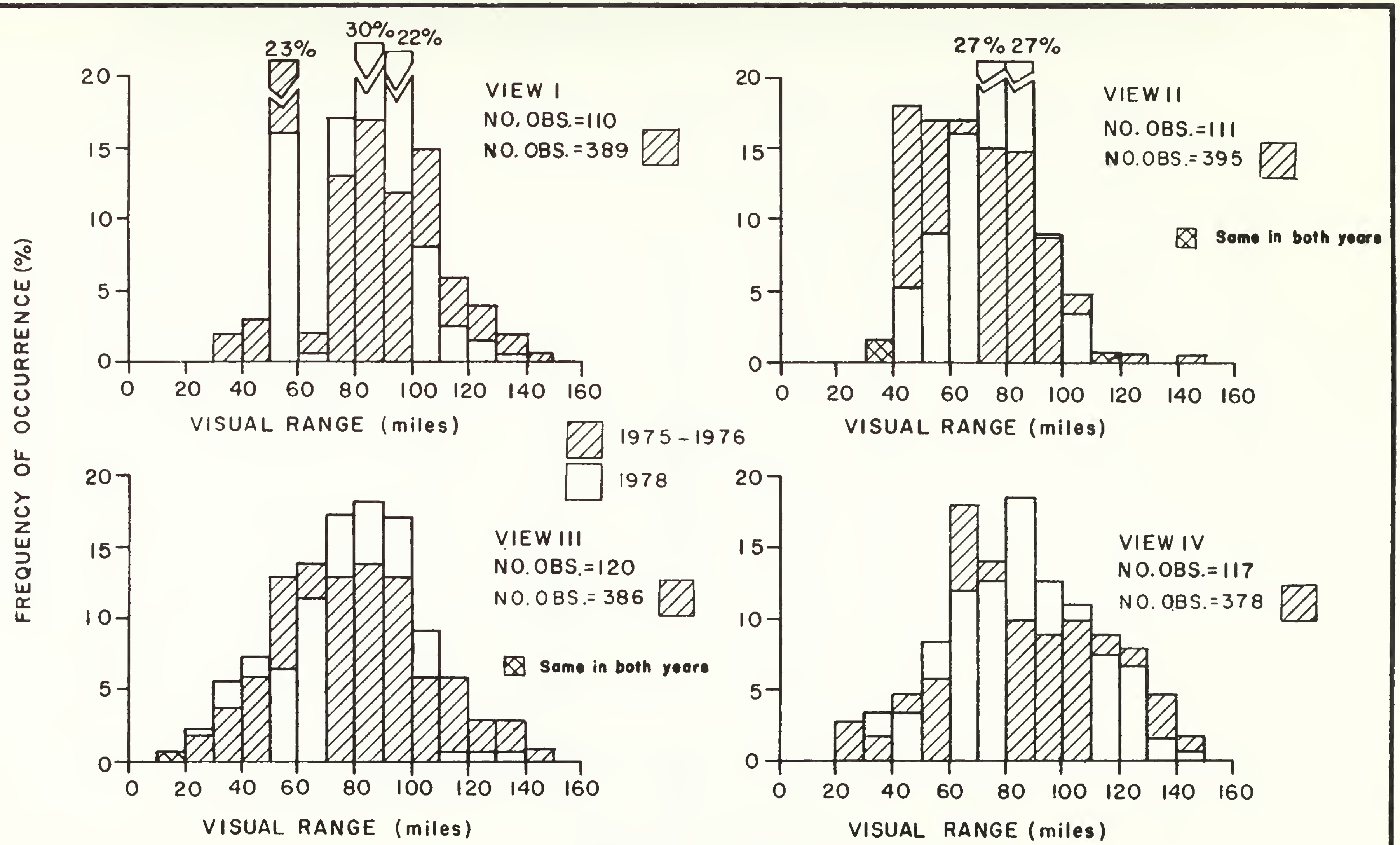


FIGURE 6.2.3-5
ANNUAL DISTRIBUTION OF VISUAL RANGE IN EACH VIEW
PICEANCE CREEK BASIN, COLORADO
SPRING and FALL, 1978

Table 6.2.3-2 COMPARISON OF PREDICTED AND ACTUAL VISUAL RANGE FOR 1978

Date	Rel. Hum. (%)	Total Prec. (in)	Part. ($\mu g/m^3$)	O_3 ($\mu g/m^3$)	Solar Rad. (Lang.)	Temp. (°C)	WS (m/s)	Max. WS (m/s)	Visual Range (mi.) Measured	Visual Range (mi.) Predicted**
4/6/78	40.	0.00	7.	103.	-	5.	5	8	102	85
4/12/78	41.	0.00	23.	82.	-	6.	2	6	94	82
4/18/78	41.	0.00	15.	87.	-	2.	2	6	81	82
4/24/78	42.	0.00	17.	81.	-	9.	2	4	83	87
4/30/78	72.	0.01	0	82.	-	5.	3	5	54	66
5/6/78	64.	0.00	0	94.	-	0.	3	6	50	67
5/12/78	44	0.00	18.	91.	714.	7.	3	4	94	85
5/18/78	56.	0.04	14.	81.	62.	6.	4	6	88	78
5/24/78	24.	0.00	28.	91.	656.	13.	8	13	66	95
5/30/78	41.	0.00	22.	79.	261.	11.	4	9	69	84
10/5/78	30.	0.00	20.	74.	434.	11.	2	4	86	98
10/11/78	39.	0.00	32.	74.	398.	15.	2	5	80	86
10/17/78	34.	0.00	29.	80.	168.	14.	4	8	78	90
10/23/78	70.	0.00	10.	50.	316.	3.	2	3	100	75
10/29/78	33.	0.00	1.	41.	309.	11.	5	20	79	87
11/4/78	44.	0.00	12.	69.	273.	10.	3	11	90	79
11/10/78	83.	0.00	12.	45.	94.	-4.	2	8	46*	56
11/16/78	84.	0.00	2.	67.	140.	-7.	1	4	29*	55
11/22/78	55.	0.00	4.	69.	209.	3.	4	14	55*	69
							Spring Mean		78	81
							Fall Mean		86	86
							Annual Mean		81	83

*Based on less than 50% data recovery; not counted in means; corresponding predicted values also not counted.

** Regression equation using the eight regression coefficients from Table 6.2.3-1 used for prediction is:
$VR = 146 - 0.20\ PA + 2.79\ WS - 0.002\ SR - 0.26\ OZ - 0.81\ RH + 0.07\ TP - 6.42\ PR - 1.80\ MW$
Symbols and units are given in Table 6.2.3-1

6.2.3.6 Conclusions

1. No time trends in visual range are detectable based on presently available data.
2. The influence of meteorological parameters on visual range is not yet sufficiently well defined to allow estimation of daily visual ranges, although seasonal and annual means may be estimated with more confidence. Additional analysis should attempt to identify additional correlative parameters.

6.3 Meteorology

6.3.1 Climatological Records

6.3.1.1 Scope and Rationale

These climatological parameters include temperature, solar radiation, precipitation, evaporation, relative humidity, and barometric pressure.

The justification for climatological records is primarily to serve as a historical data base to assess climatological effects principally on the biotic portion of ecosystem so they may subsequently be sorted out from potential man-induced effects.

6.3.1.2 Objectives

Objectives are to establish this historical data base and to determine any cyclical or long-term trends that might exist as well as averages and extremes, as appropriate.

6.3.1.3 Experimental Design

Parameters measured, instrumentation used, sampling stations (Figure 6.3.1-1) and min. reporting frequency are presented in Table 6.3.1-1.

6.3.1.4 Methods of Analysis

Table 6.3.1-2 presents a summary of data formats and analysis along with station identification. Data presentation and analysis techniques include Box-Jenkins time series for temperature, time series plots for all Class I indicator variables, histograms, plots and tables. In the cases of solar radiation and precipitation the methods include techniques for monthly and annual totals in presence of missing data.

6.3.1.5 Results and Discussion

6.3.1.5.1 Temperature

Annual mean temperatures at the Tract (Sta.AB23) have averaged between 6 and 7°C over the past four years. Box-Jenkins analysis of the monthly means (Table A6.3.1-1) yielded a total (4 year) series mean of 6.05°C with no discernable trend; projections over the next year with 95% confidence using a seasonal autoregressive model are shown on Figure 6.3.1-2.

Between-station comparisons (Sta.AB20 vs. AB23) indicate minimum temperatures 18 to 21°C cooler in Piceance Valley than on Tract, due principally to cold air drainage associated with katabatic winds, with Valley temperatures reaching extremes of -43°C.

FIGURE 6.3.1-1
CLIMATOLOGICAL NETWORK

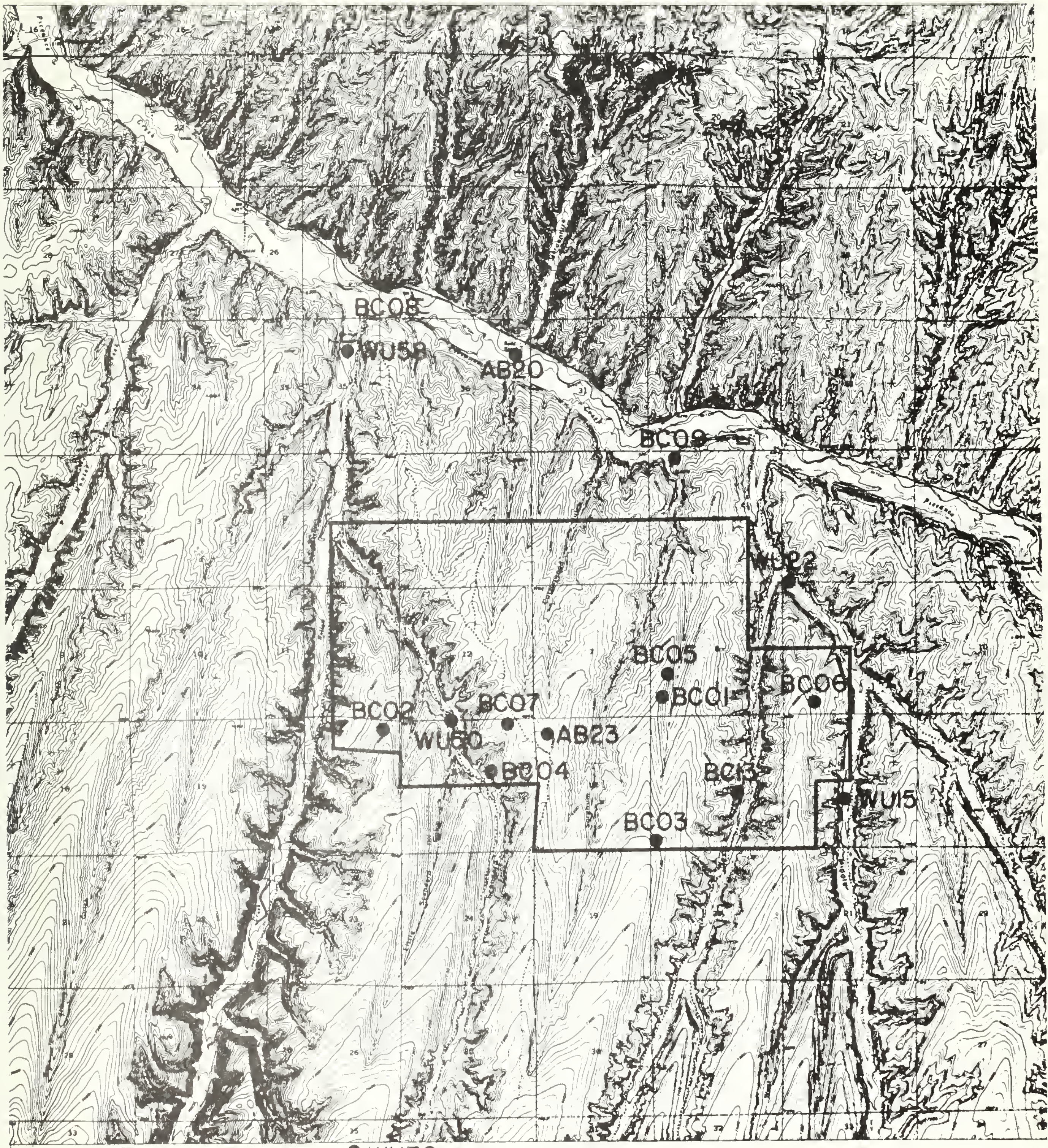


TABLE 6.3.1-1

CLIMATOLOGICAL PARAMETER EXPERIMENTAL DESIGN

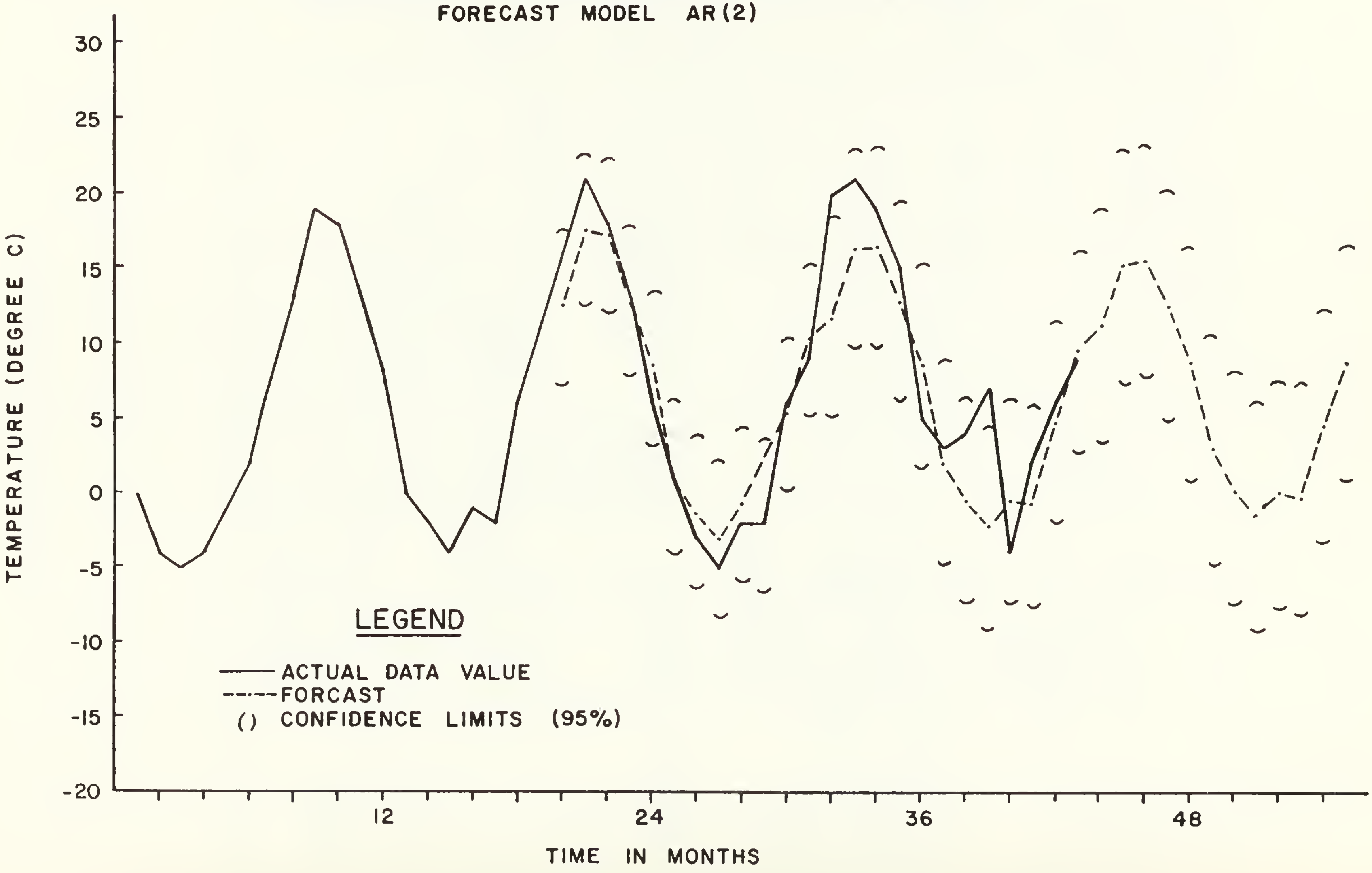
PARAMETER	INSTRUMENT	STATION(S)	COMPUTER CODE	MINIMUM REPORTING FREQUENCY
Air Temperature	Aspirated Temperature Sensor	020	AB20	Hourly
		023	AB23	Hourly
		042	AD42	Hourly
		056	AD56	Hourly
Direct Solar Radiation	Pyranometer	023	AB23	Hourly in daylight
Precipitation	Weighing Bucket	020	AB20	Hourly
		023	AB23	Hourly
		USGS015	WU15	Approx. Monthly Totals
		USGS022	WU22	Approx. Monthly Totals
		USGS050	WU50	Approx. Monthly Totals
		USGS058	WU58	Approx. Monthly Totals
		USGS070	WU70	Approx. Monthly Totals
	Tipping Bucket	MC1 to 9, 13	BC01 to 09, 13	Bi-Weekly
Evaporation	Pan	023	AB23	Daily
Relative Humidity	R. H. Sensor	023	AB23	Hourly
Barometric Pressure	Barometer	023	AB23	Hourly

TABLE 6.3.1-2

CLIMATOLOGICAL DATA SUMMARY

VARIABLE	ITEM	STA.	TYPE PRESENTATION/ ANALYSIS	FIGURE/ TABLE NO.
Air Temperature	Monthly Mean	AB23	Box Jenkins Time Series	Fig. 6.3.1-2 Tab. A6.3.1-1
	Daily Mean, Min, Max	AB20,23 AD42,56	Time Series Plots	Fig. B6.3.1-2,3 Fig. B6.3.1-4,5
	Monthly Values of Hrly Max, Mean, Min,	AB20,23	Tabular	Tab. A6.3.1-2
	Growing Season	AB23	Plot Table - Start, End, Length	Fig. 6.3.1-3 Tab. A6.3.1-3
	Degree Days	AB23	Tabular	Tab. A6.3.1-3
Direct Solar Radiation	Daily Total	AB23	Time Series Plot	Fig. B6.3.1-7
	Daily Mean; Max & Min for Month	AB23	Tabular - Values Corrected for missing data	Tab. A6.3.1-4
Relative Humidity	Daily Mean, Min, Max	AB23	Time Series Plot	Fig. B6.3.1-1
	Monthly Values of Hrly Max, Mean & Min	AB23	Tabular	Tab. A6.3.1-5
Precipitation	Daily Total	AB20,23	Time Series Plots	Fig. B6.3.1-9, 10
	Monthly Total	AB20,23 WU15,22 WU50,58 WU70 BC01 to 09, 13	Averages over all Sta ± the micro-climate sta; approx. annual total	Tab. A6.3.1-6a thru 6d
	Monthly Total	AB23	Histogram (with Growing Season)	Fig. 6.3.1-3
	1-Hr Max	AB20,23	Tabular	Tab. 6.3.1-3
	3 Mo. Sliding Total	AB23	Tabular	Tab. 6.3.1-3
	Between Sta Compar.	AB20,23	Histograms	Fig. 6.3.1-4
Evaporation	Daily Mean	AB23	Time Series Plot (Pan)	Fig. B6.3.1-11
	Daily Mean	AB23	Tabular - Pan & Lake	Tab. A6.3.1-7
Barometric Pressure	Daily Mean, Min, Max	AB23	Time Series Plot	Fig. B6.3.1-6
	Monthly Values of Hrly Max, Mean & Min	AB23	Tabular	Tab. A6.3.1-8

FIGURE 6.3.1-2
TEMPERATURE AT TRAILER AB23 (10M LEVEL) vs. TIME
FORECAST MODEL AR(2)



Growing season and degree-day data are presented on Table A6.3.1-3. Growing seasons over the past four years have varied from 111 days in 1976 to 144 days in 1977, yet the degree-days referenced to 18°C (Munn (1970)) were highest in 1978 (223°C-days) indicating the highest average temperatures and corresponding to a growing season of 124 days.

6.3.1.5.2 Solar Radiation

Direct solar radiation as measured by the pyranometer varies from a monthly average of 620 langleys per day in June near summer solstice to approximately 130 in December near winter solstice. This variation approximates the yearly cycle in the peaks of cosine of the sun's zenith angle. Values presented in Table A6.3.1-4 have been corrected for missing data by applying a correction factor. This correction factor is the ratio of average daylight hours per month to pyranometer channel "uptime" hours per month for cases where uptime exceeds 50% of the daylight hours per month. Values obtained for the Tract in June have been compared with values obtained for 40°N latitude (approx. Tract latitude) from Sellers, Physical Climatology (Figure 5):

	TRACT	SELLERS
Clear day peak	744	700 ly/day
Monthly average	620	592

Sellers "average" terms included:

Q,	direct beam solar radiation incident on earth surface	
+q,	diffuse solar radiation incident on earth surface	389 ly/day
Cr,	backscattering by clouds	164
Ar,	backscattering by air molecules, dust, water vapor	39
	Total	592 ly/day

Additional terms in Sellers peak (cloudless, dry day)

C_a,	(no) absorption by clouds	25
A_a,	(no) absorption by air molecules, dust, water vapor	83
	Total	700 ly/day

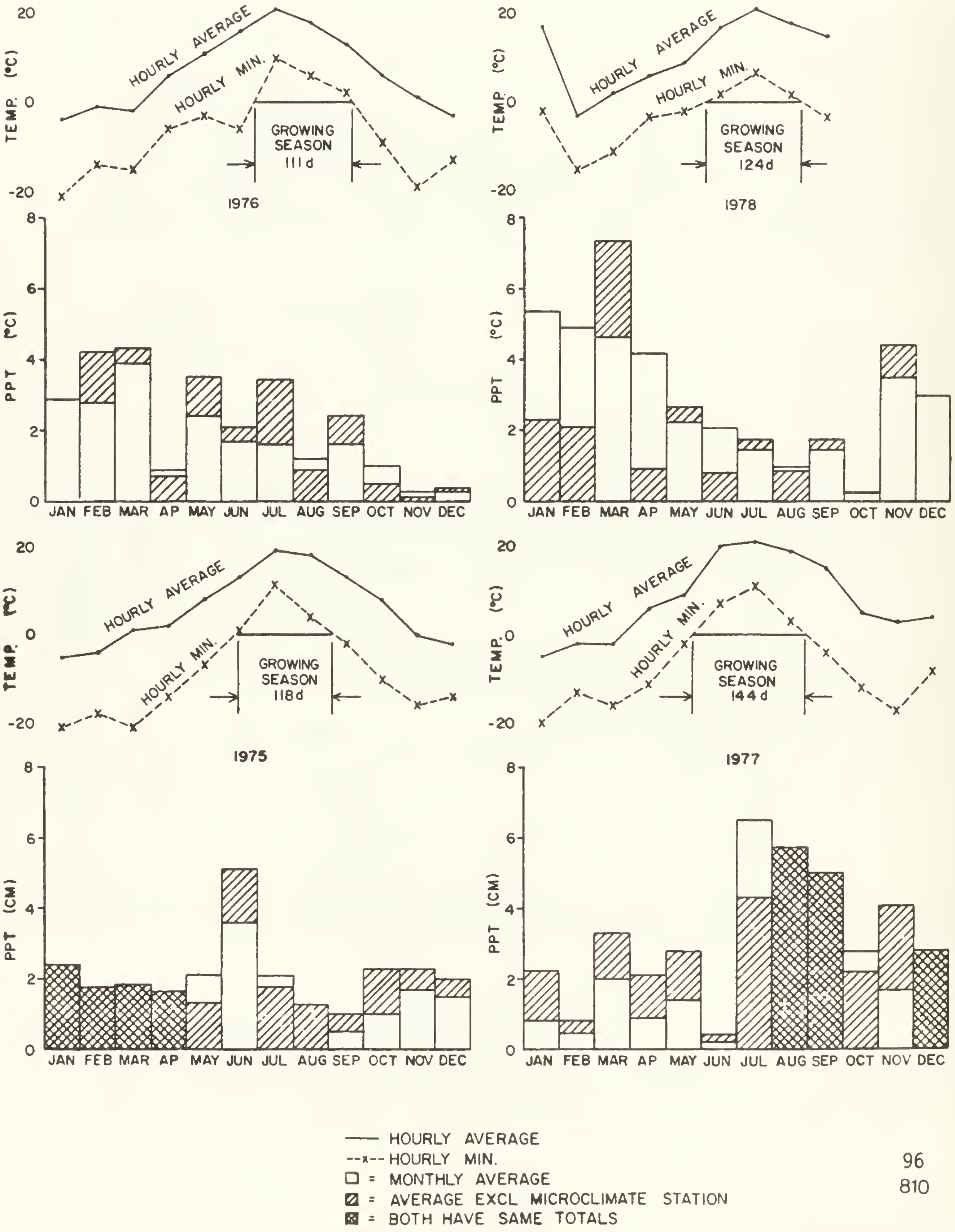
6.3.1.5.3 Relative Humidity

Annual mean relative humidity at the Tract, (Sta. AB23) has averaged between 54 and 56% over the past 4 years, with winter hourly minimums to 10 and summer minimums to 9 (Table A6.3.1-5).

6.3.1.5.4 Precipitation

Precipitation data, as indicated on Figure 6.3.1-1 and Table 6.3.1-1 include measurements near two air quality stations, 4 USGS stream gaugung stations, 1 USGS station on the Roan Plateau, and 10 microclimate stations (under canopies). Monthly averages over all stations

FIGURE 6.3.1-3
MONTHLY TOTAL PRECIPITATION
AND TEMPERATURE VARIATIONS



are presented in Tables A6.3.1-6a through -6d. Monthly averages at the USGS stations are approximate only, inasmuch as sampling of these stations is somewhat randomized. Annual totals (± the microclimate stations and excluding the Roan Plateau station for which precipitation is higher than the Tract locale), 3-month running totals and the 1-hour peaks for the past four years are given on Table 6.3.1-3. Monthly histographs for each year are presented on Figure 6.3.1-3, along with growing season information. Although 1977 was the wettest of the four years, (35.7 cm), its distribution was such that it came too late in the year to be a major influence on productivity (see the late peak in May-July), a fact borne out in the ecosystem interrelationships section. Lightest annual precipitation was 23.6 cm in 1976. Peak down-pours for a 1-hour duration have reached 4.3 cm on September 3, 1977. Between-station comparisons for AB20 and AB23 are portrayed on Figure 6.3.1-4 as histograms, showing the local nature of precipitation between Tract (AB23) and Valley (AB20). Differences in monthly totals of as much as 5.4 cm were observed in September 1977.

6.3.1.5.5 Evaporation

Evaporation during the growing season has been measured by an evaporation pan at Sta. AB23 in 1978. Monthly totals (Table A6.3.1-7) ranged from 17.7 to 27.0 cm, as "pan" values; assuming a 0.7 pan coefficient, lake values respectively range from 12.4 to 18.9 cm.

6.3.1.5.6 Barometric Pressure

Annual mean barometric pressures at Tract Sta. AB23 have averaged approximately 790 mb over the past four years with hourly minimums as low as 753, and hourly maximums as high as 804 mb, (Table A6.3.1-8).

TABLE 6.3.1-3

PRECIPITATION (cm)

YEAR	ANNUAL TOTAL*		3-MONTH TOTAL* (Incl. Micro. Sta)			1-HOUR MAXIMUM	
	EXCLUSIVE OF MICROCLIMATE STATIONS	INCLUDING MICROCLIMATE STATIONS	MAR-APR-MAY	APR-MAY-JUN	MAY-JUN-JUL	AMOUNT	DATE
1975	24.95	24.86	5.74	7.53	8.06	1.19	AUGUST 14
1976	23.64	21.46	8.10	5.91	5.66	0.51	MAY 6
1977	35.74	30.35	4.38	2.52	8.15	4.32	SEPTEMBER 3
1978	34.94	25.51	11.80	8.72	5.93	1.35	MAY 21

* Obtained from Monthly averages over all stations in vicinity of Tract (Excluding the Roan Plateau Station)

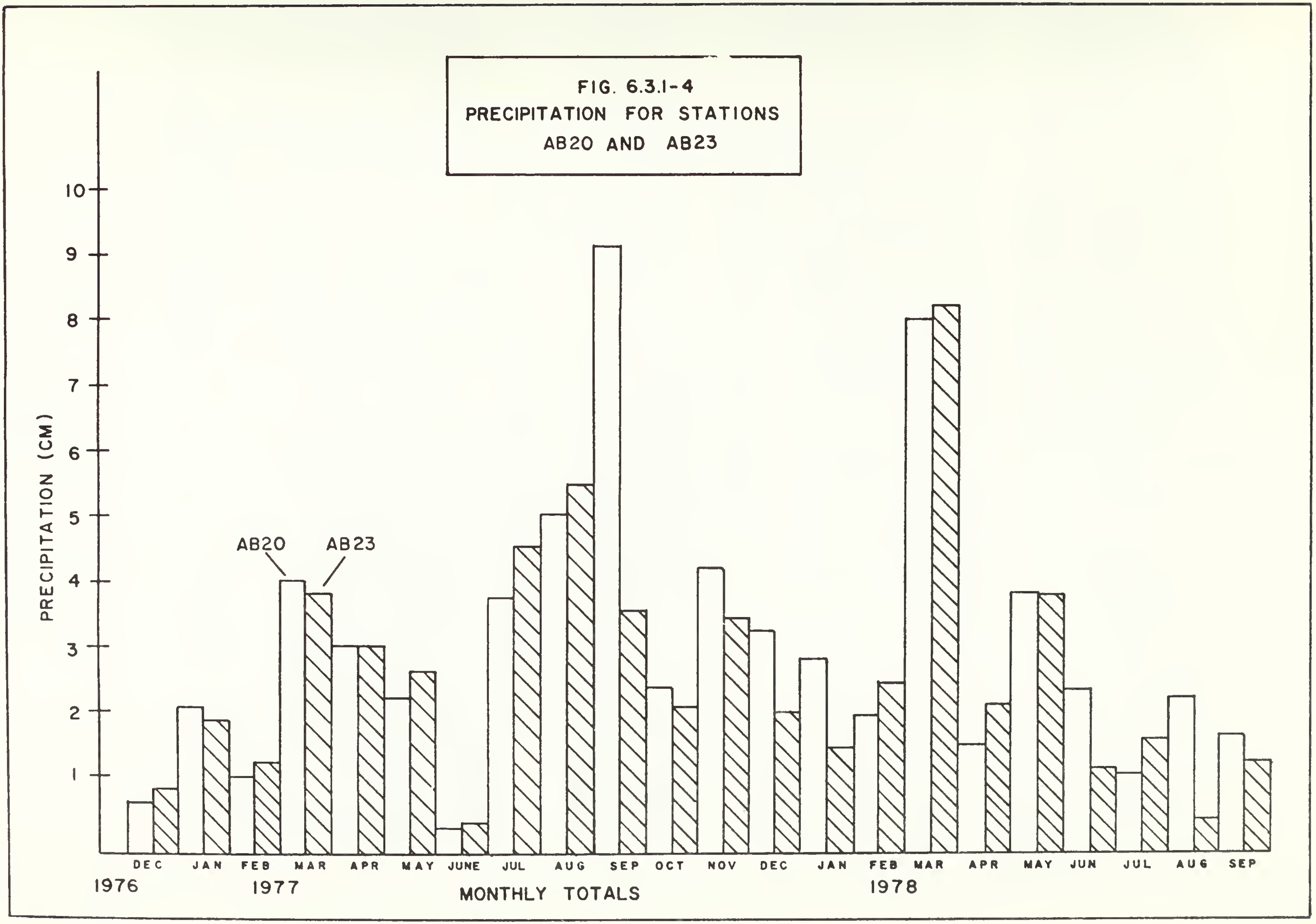


FIG. 6.3.1-4
PRECIPITATION FOR STATIONS
AB20 AND AB23

6.3.2 Wind Fields

6.3.2.1 Scope and Rationale:

This section analyzes the wind field data collected at the meteorological tower, and stations AB20, AB23, AB24, AD42, and AD56. Data consist of wind speed, wind direction, vertical variations in horizontal wind speed and wind direction, stability class, and upper air characteristics as determined by double theodolite, temperature-instrumented pilot balloon, acoustic-radar, and tethersonde soundings. Wind flow patterns and stability class provide information for diffusion modeling and pollutant transport and concentration. A summary of tracer test conducted in September 1978 is included as a specific analysis of typical meterological conditions in support of diffusion modeling.

6.3.2.2 Objectives:

The objectives of this program are:

a) to refine the knowledge of the wind fields in the vicinity of the C-b Tract.

b) to provide supporting information for air quality data analysis.

c) to provide inputs for air diffusion modeling.

6.3.2.3 Experimental Design:

Sampling frequency for wind data is identical to that of the air quality parameters.

Parameters measured are shown in Table 6.3.2-1.

TABLE 6.3.2-1 WIND FIELD PARAMETERS AND STATIONS

Parameter	Instrument	Station
10-m horizontal wind speed	Anemometer	AB20,AB23,AB24,AD42,A
10m-horizontal wind direction	Vane	" " " "
30-m, 60-m horizontal wind speed	Aneometer	Met Tower (AA23)
30-m, 60-m " " direction	Vane	" " "
10,30 60-m horizontal wind dir. std. deviation*	Vane	" " "
ΔTemp. (60m to 10m)	ΔT Sensor	" " "
Mixing layer height	Acoustic Radar	AB20
Winds aloft:		
Speed and direction	Double theodolite,	AB24
Temperature	Temp. instrumented minisonde or pibal	AB24

* Computed quantity

Thus with the above measurements the near-surface (10m) wind field is assessed at five stations.

The winds-aloft study was a joint C-b, EPA study conducted for a one-year period (October 1977-78)

Near-surface wind fields are determined from continuous monitoring of winds at the 10 meter height. The meteorological tower levels along with acoustic radar and pibal trajectories provide data for vertical wind structure and stability conditions important for determining plume rise and for diffusion modeling.

6.3.2.4 Method of Analysis:

Analysis in this section consists of comparisons of wind field data over time and between sites. Temporal comparisons are made by comparing quarterly wind roses over several years at a given site and elevation. Seasonal differences are noted. In addition, time series plots are presented for winds at mixing-layer and inversion heights on Figures B6.3.2-1 to -12. Spatial comparisons consist of comparisons of wind roses, inversion-height statistics, and pibal temperature - altitude profiles with identical or comparable data collected at different sites. A study of the translatability of acoustic sounder data taken in Piceance Creek to the C-b Tract area is reported.

6.3.2.5 Results and Discussion:

The Environmental Baseline Final Report Volume 3, presents some detailed analyses of wind field data. Data collected since that report have been less extensive. Analyses presented here are in the form of extensions of some of the studies previously reported. It is discussed in three parts: a) near-surface wind fields, b) upper-air wind structure, and c) summary of tracer test conducted on September 14, 1978.

6.3.2.5.1 Near-Surface Wind Fields

Determination of predominant wind speed and wind directions can be made by examination of quarterly wind-roses over the seasons and from year to year. Figures A6.3.2A-1 through A6.3.2A-8 present the quarterly wind rose plots for two years for the various meteorological stations. A summary of the predominant wind direction and speeds is presented in Table 6.3.2-2. The predominant wind direction at the meteorological tower is SSW and there is virtually no change from year to year. Fall and winter quarters have lower wind speeds than spring and summer at the 10 meter level. However, at the 30 meter level the wind speed difference between the quarters is less. As expected, wind speeds at 30 meter level are higher than at the 10 meter level.

Stations located in or near Piceance Creek Valley (AB20, AD42, AD56) tend to show downstream (drainage) flow at night (E-ESE) and upstream flow (W-WNW) in daytime at all stations and for all seasons with drainage predominant.

TABLE 6.3.2-2 WIND ROSE COMPARISON AND OBSERVATIONS

Site	Quarter	Predominant Wind Direction and Speed 1974-1975	1975-1976	1976-1977	1977-1978
Tower (AA23) 10 meter	Fall			SSW (1-3)	SSW (<1)
	Winter			SSW (1-3)	SSW (1-3)
	Spring			SSW (5-8)	SSW (3-5)
	Summer			SSW (5-8)	SSW (5-8)
Tower (AA23) 30 meter	Fall	S (5-8m/sec)	SSW (5-8)	SSW (5-8)	SSW (5-8)
	Winter	SSW (5-8)	SSW (5-8)	SSW (8-11)	SSW (3-5)
	Spring	SSW (5-8)	SSW (5-8)	SSW (8-11)	S (3-5)
	Summer	SSW (5-8)	SSW (5-8)	SSW (5-8)	SSW (5-8)
AB20 10 meter	Fall			E (1-3)	
	Winter				
	Spring				ESE (1-3)
	Summer				E (1-3)
AD42 10 meter	Fall				
	Winter				
	Spring				ESE (1-3)
	Summer				E (1-3)
AD56 10 meter	Fall				
	Winter				
	Spring				SE (1-3)
	Summer				SE (1-3)

6.3.2.5.2 Upper-Air Wind Structure

Three analyses are presented in this section: a) Acoustic radar inversion and mixing data and the representativeness of the data to the C-b Tract area; b) double-versus single-theodolite pibal profiles; and c) atmospheric stability.

a) Inversion and Mixing Heights

Temperature inversion heights are measured by means of an AeroVironment Model 300 Acoustic Radar. The instrument was reactivated at Piceance Creek station AB20 in November 1977. The output of the instrument is a continuous strip chart record of reflected sound signals associated with thermal turbulence signatures; such signatures vary in character depending on whether the atmosphere is stable or unstable. The chart provides a means for determining the height in meters of temperature inversions and mixing layers above ground level.

Figure A6.3.2A-9 shows average monthly inversion heights for months of December 1977 through August 1978. The months are grouped by quarters to show seasonal patterns. Plots have been limited to hours with expectation of occurrence greater than 0.5. Winter months show average inversion heights of about 175 meters above ground level. The average afternoon onset time is 1830 hours and breakup the next morning about 1100 for an average duration of 16-1/2 hours. Spring months show average inversion heights of 200 meters. Onset time is about 1 hour later at 1930 and breakup is about 0900 the next morning. Average duration is 13-1/2 hours. The plots show the greatest average height range for the summer months with June averaging 300 meters, July averaging 350 meters, and August with 400 meter average. Duration in summer is shorter with average onset time of 1930 and breakup next morning about 0830 for about 13 hours average duration.

Constant potential temperature and constant pressure lines on a cross section plot of elevation profiles from Piceance Creek to the C-b Tract are presented on Figures A6.3.2A-10 and -11 for two dates corresponding to tethersonde balloon flights. It is expected that inversion height profiles approximate lines of constant potential temperature as they exist on the same date. The acoustic radar is located at station AB20, the lowest point on the profile. Inversion heights in meters above this station can be translated to heights above the meteorological tower and compared with the constant potential temperature lines. The top of the 60 meter meteorological tower translates to 225 ± 25 meters above the acoustic radar at site AB20.

To investigate the translatability of acoustic radar data observed in Piceance Creek to the C-b Tract, a comparison of inversion height measurements taken in 1975 and 1976 were made. Two acoustic radars were operational, one at the meteorological tower site and the other in Piceance Creek first at site AC21 and in June 1976 moved to site AC20. It has been possible to screen from the statistics inversions that were observed concurrently at both stations. Table 6.3.2-3 shows the monthly mean inversion duration and heights of the concurrent

TABLE 6.3.2-3 MONTHLY MEAN INVERSION HEIGHTS OBSERVED CONCURRENTLY AT TWO SITES

Site	Year	Month	Mean(Hours) Duration	Mean Max. Height(m)	Mean Min. Height(m)	Mean Avg. Height(m)
AB21	75	Nov.	18.09	278.11	65.36	198.29
AB23	75	Nov.	12.73	161.85	45.47	99.09
AB21	75	Dec.	15.50	260.91	65.84	167.34
AB23	75	Dec.	16.80	195.99	60.05	113.57
AB21	76	Jan.	11.38	399.48	143.18	292.76
AB23	76	Jan.	14.31	219.99	65.04	145.43
AB21	76	Feb.	17.38	369.38	98.03	268.15
AB23	76	Feb.	15.06	322.59	52.65	161.89
AB21	76	Mar.	12.82	322.62	57.14	218.24
AB23	76	Mar.	10.85	191.18	60.13	123.97
AB21	76	Apr.	14.38	307.39	44.81	212.67
AB23	76	Apr.	10.38	150.04	49.99	98.76
AB21	76	May	8.40	459.09	208.42	370.88
AB23	76	May	10.20	250.03	70.01	157.52
AB21	76	Jun.	7.00	569.98	249.94	480.52
AB20	76	Jun.	8.56	508.25	203.68	394.03
AB23	76	Jun.	9.00	262.04	81.96	159.68
AB20	76	Oct.	12.83	392.58	138.56	313.74
AB23	76	Oct.	11.67	250.04	88.32	164.26

observations at each site. Figure A6.3.2A-10 and A5.3.2A-11 also show June and October 1976 monthly max, mean, and min inversion heights plotted on the elevation profiles of constant potential temperature surfaces for specific dates. The constant potential temperature surfaces were determined by tethersonde flights on the dates.

Mixing heights are also obtained from the acoustic radar records. As the ground-based inversion begins to breakup in the morning, surface temperature may rise faster than the upper air temperature resulting in a condition described as an inversion aloft. The temperature-altitude profile is similar to that in Figure 6.3.2-1 with the mixing height increasing until it is equal to inversion height. Similar conditions can occur with movements of warm and cold fronts. The air within the mixing height layer is described as neutral or unstable and provides for good mixing and diffusion of stack emissions.

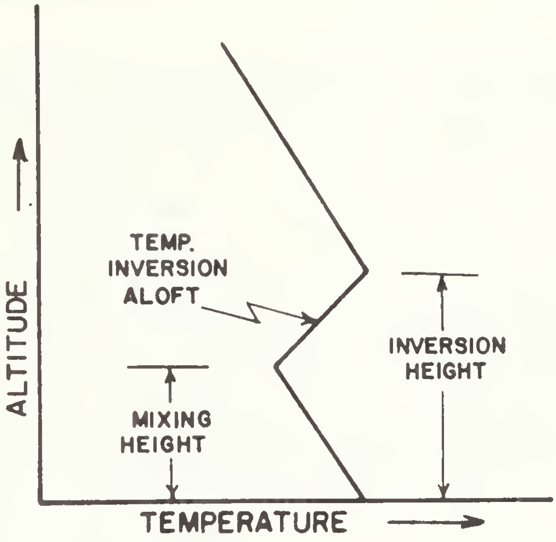


Figure 6.3.2-1 Temperature-Altitude Profile of an Elevated Inversion

However, the air layer between the mixing height and the top of the temperature inversion (increasing temperature with altitude) is stable and very little diffusion of stack emissions occurs in this air layer. Stack emissions below the mixing height are constrained by the inversion "lid". Stack emissions above the inversion height will continue to rise and will not penetrate down through the inversion.

Mixing layer heights have been plotted as a time-series plot in Figure B6.3.2-12. Data are for the period of mid-November 1977 through September 1978. Mixing heights are reported for about 70% of the days with the great majority (about 90%) being at the minimum reporting height of 30 meters. Occasional short duration heights (2 hours) of 100 to 150 meters are reported with a maximum of 425 meters reported in September 1978.

b) Pibal Single-Versus-Double Theodolite Comparison

During the period from November 1977 through October 1978, pilot balloons (pibal) were released twice daily every other day near trailer site AB24 in the early morning and afternoons. Upper air temperature, wind speed, and direction as a function of altitude were determined by tracking the ascent over several minutes and a rise through several thousand meters altitude by double theodolite. Upper-air temperature as a function of altitude was obtained through a temperature-sonde attached to the pibal. The signal transmitted from the temperature-sonde was monitored by radio receivers and used with the trajectory calculations to produce temperature-altitude profiles.

An alternative temperature-altitude profile is obtained from a single theodolite by assuming constant rate of rise and using the temperature-time measurements.

Single and double theodolite techniques for measuring upper air temperatures from the pibal data have been compared for several representative morning and afternoon launches. Typical comparative profiles are shown in Figures A6.3.2A-12 and A6.3.2A-13 for the lower 800 meter portion of the trajectories. Stack plume rise can be expected to be well below this altitude under any meteorological condition. Single and double theodolite trajectories show similar profiles with respect to temperature-inversions and temperature lapse rates. Altitude for a given temperature was significantly different (approximately 100 meters) in 40 percent of the comparisons; good agreement is achieved in 60 percent of the comparisons. The presence of an inversion is identified and its altitude error is no greater than 100 meters. It is concluded from this comparison that either single or double theodolite determination of temperature-altitude profiles is adequate for air diffusion modeling inputs to be used for permit applications.

c) Stability Class Study

Monthly average stability classes have been derived from hourly stability class data. The hourly stability classes were based on delta temperature measurements between the 60 meter and 10 meter levels on the meteorological tower. Pasquill-Gifford stability classes were determined from the slope of the temperature altitude curve (dt/dz) and adjusted for wind speed by the method described in the Baseline Report, Volume 3. Monthly averages by hour from the period from November 1976 through September 1978 are shown in Table 6.3.2-4 for the months containing more than 50% of the data. Unstable, neutral, and stable class are indicated by shading.

Comparison of these data with the baseline period (data shown in Table 6.3.2-5) shows similar patterns for the broad classifications of unstable, neutral, and stable classes. The period for November 1976 through May 1977 is very similar to the same months in the baseline years. However, 1978 data for January-March and July-September tended to reflect a shift in stability class toward the stable end of the scale (toward class F) by one Pasquill-Gifford stability class for most of the monthly averages by hour. No clear explanation can be identified for this.

TABLE 6.3.2-4 AVERAGE HOURLY STABILITY CLASSES (1976 - 1978)

SOURCE: Temperature differences between 60 meter and 10 meter on the Met Tower (Adjusted for Wind Speed)

Month	HOUR																								Average
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
Nov. 1976	E	D	D	E	D	E	E	E	D	A	A	B	B	B	B	B	B	D	D	D	E	E	E	E	D*
Dec.	E	E	E	E	E	E	E	E	E	C	B	B	B	B	B	B	B	D	D	D	E	E	E	E	D
Jan. 1977	D	D	E	D	E	D	D	E	D	C	B	B	B	B	B	B	B	C	D	D	D	D	D	D	C
Feb.	E	E	E	E	E	E	E	E	D	C	A	B	B	B	B	B	B	B	C	D	D	D	D	E	D
Mar.	D	D	D	D	D	D	D	C	B	B	C	C	C	C	C	C	C	B	C	D	D	D	D	D	C
Apr.	D	E	E	E	D	E	D	B	B	B	B	B	C	C	C	C	C	B	C	D	D	E	D	D	C
May *	D	D	D	D	D	D	D	B	C	C	D	C	C	D	D	D	D	D	C	D	D	D	D	D	C
June^1																									
July^1																									
Aug.^{1}																									
Sept.^{1}																									
Oct.^{1}																									
Nov.^{1}																									
Dec.^{1}																									
Jan. 1978	E	E	E	E	D	E	E	E	E	D	D	D	D	D	D	D	D	D	E	E	E	E	E	E	E
Feb. *	E	E	E	E	E	E	E	E	E	D	D	D	D	D	D	D	D	D	E	E	E	E	E	E	E
Mar. *	E	E	E	E	E	E	E	E	D	D	D	D	D	D	D	D	D	D	E	E	E	E	E	E	E
Apr.^{1}																									
May^1																									
June^1																									
July *	F	F	F	F	F	F	F	D	D	D	D	D	D	D	D	D	D	D	D	E	E	E	E	F	E
Aug. *	F	F	F	F	E	E	E	E	D	D	C	C	C	C	C	D	D	D	D	E	E	E	F	F	E
Sept. *	F	F	F	F	F	F	F	E	D	D	D	D	D	D	D	D	D	D	E	E	E	E	E	E	E

TABLE 6.3.2-5 AVERAGE HOURLY STABILITY CLASSES (1974 - 1976)

SOURCE: Temperature differences between 60 meter and 10 meter on the Met Tower (Adjusted for Wind Speed)

Month	Hour																								Average
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
Nov.*																									
Dec.*																									
Jan.75	D	D	D	D	D	D	D	D	E	E	E	E	D	D	D	D	D	D	D	E	D	D	D	D	D
Feb.	E	E	E	E	E	E	E	E	E	D	D	C	D	C	C	D	D	E	E	E	E	E	E	E	E
Mar.	D	D	D	D	D	D	D	D	C	C	C	C	C	C	D	D	C	C	D	D	D	D	D	D	D
Apr.	D	D	D	D	D	D	D	B	C	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D	C
May	D	D	D	D	D	D	D	B	B	B	C	C	C	C	C	C	C	C	C	C	D	D	D	D	C
June	E	E	E	E	E	E	D	B	D	B	B	C	C	B	C	C	C	C	C	C	D	D	E	E	D
July	-	-	-	MISSING DATA					-	-	-	B	B	B	B	B	B	C	-	-	-	-	-	-	B
Aug.	F	F	F	F	F	E	E	E	C	B	C	C	C	C	C	C	C	C	D	E	E	F	E	E	D
Sept.	F	E	E	F	F	F	F	E	B	B	B	B	B	C	B	D	C	B	E	E	E	F	F	F	D
Oct.	E	E	E	E	E	E	E	E	C	B	B	C	B	C	C	C	B	C	D	D	E	E	E	E	D
Nov.	D	D	D	D	D	D	D	D	C	B	B	B	C	B	B	B	B	C	D	D	D	D	D	D	D
Dec.	D	D	D	D	D	D	D	D	C	C	B	B	B	B	B	B	B	C	C	C	D	D	D	D	C
Jan.76	D	D	D	D	D	D	D	D	D	C	B	B	B	B	D	B	B	B	C	C	D	D	D	D	D
Feb.	D	D	D	D	D	D	D	D	C	C	C	C	C	C	C	C	B	B	C	D	D	D	D	D	C
Mar.	D	D	D	D	D	D	D	C	C	C	B	D	C	C	C	B	C	C	D	C	C	C	C	C	C
Apr.	D	D	D	D	D	D	D	B	B	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D	C
May	E	E	E	E	E	E	D	B	B	B	B	B	B	B	D	D	B	B	C	D	D	E	E	E	C
June	E	E	E	E	E	E	E	C	C	C	C	C	C	C	C	C	C	C	C	D	E	E	E	E	D
July	E	E	E	E	E	F	E	B	B	B	B	B	B	C	B	B	B	B	B	D	E	E	E	E	D
Aug.	E	E	E	E	E	E	E	C	B	B	C	C	C	C	C	C	C	C	C	E	E	E	E	E	C
Sept.	E	E	E	E	E	E	E	D	B	B	B	B	B	B	B	D	B	B	D	D	D	E	E	E	D
Oct.	E	E	E	E	E	E	F	B	B	B	B	B	B	B	B	B	B	C	D	E	E	E	E	E	D

* Partial data only, less than 100% but more than 50%

1 Missing data

Key:

▧	Unstable Class
D	Neutral
☐	Stable Class

Table 6.3.2-6 presents the percentage of hours in each stability class for each month. The baseline data are included for comparison. This table also reflects the shift to the more stable classes for 1978.

Typically the hours between 0900 and 1900 are unstable. Nighttime and early mornings for summer and fall are typically stable while winter and spring are neutral stability.

6.3.2.5.3 Summary of Tracer Test Conducted on September 14, 1978

An experiment was conducted on the C-b Shale Oil Tract on September 14 and 15, 1978 with the objective of simulating the transport and dispersion of emissions from an elevated source in the vicinity of the proposed ancillary facility under meteorological conditions conducive to high ground level pollutant concentrations. Oil Shale Tract C-b Development Monitoring Report #1 (1978) contains a complete report of the tests. The results of the meteorological measurements and related analyses for the September 14 test are summarized in Appendix A6.3.2B as relevant analyses of the wind field conditions and gas concentrations under conditions frequently existing on the Tract.

Figure 6.3.2-2 shows isopleths of SF_6 for September 14 constructed from observed data.

In the first hour, high concentrations of SF_6 were detected at the mouth of Cottonwood Gulch. SF_6 was also detected along the Piceance Creek east of the mouth of Cottonwood Gulch. This is definitely due to the influence of the drainage wind system. Concentrations were higher on the southern bank of Piceance Creek than on the northern bank. Air flowing down the northern slope of the creek (drainage) kept the SF_6 from building up on the northern bank.

A similar pattern was observed in the second hour (0700-0800 MDT). In the following hour the tongue flowing down Cottonwood Gulch into Piceance Creek was almost non-existent.

After 0900 MDT, the SF_6 isopleths showed that high concentrations were observed only south of the point of release. Although fumigation of the plume definitely occurred during the hour beginning 0900 MDT, its duration must have been very short and thus did not result in any high concentrations when averaged over an hour. SF_6 was still detected along the creek during the last two hours, not because the plume was over the creek, but because the flow reversal (from drainage to upslope) brought back SF_6 that was earlier transported down the creek.

A number of observations can be deduced from the results of the experiment.

(1) On 14 September, when the synoptic pressure gradients were weak, local meteorology was responsible for the transport and diffusion of pollutants during nighttime and early morning hours. Under such a situation, the synoptic wind flow was not able to establish itself until after mid-day.

Table 6.3.2-6

METEOROLOGICAL SUMMARY: STABILITY CLASS FREQUENCIES (%)

Source: Met. Tower[1]
(30' to 200'

Pasquill-Gifford Stability Class	dT/dz Range[1] for this Stability Class (^{0}C/100m)	1974		1975										Annual Mean
		Nov.[2]	Dec.[2]	Jan.	Feb.	Mar.	Apr.	May	June	July[3]	Aug.	Sept.	Oct.	
A	<-1.9			8.3	1.0	1.1	12.0	7.4	8.6	0.0	2.4	5.8	8.1	6.1[4]
B	-1.9 to -1.7			5.5	4.4	10.3	23.5	30.6	25.6	85.7	19.3	23.4	20.6	18.1
C	-1.7 to -1.5			4.1	2.4	16.3	6.9	9.3	6.9	14.3	6.1	5.0	5.7	7.0
D	-1.5 to -0.5			33.0	43.4	60.9	36.3	30.0	27.0	0.0	25.8	13.4	28.3	33.1
E	-0.5 to +1.5			33.3	36.8	11.4	18.1	12.1	18.0	0.0	17.3	24.4	18.6	21.1
F	>1.5			15.8	12.0	0.0	3.2	10.6	13.9	0.0	29.1	28.0	18.7	14.6
Total Percentage				100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Pasquill-Gifford Stability Class	dT/dz Range[1] for this Stability Class (^{0}C/100m)	1975		1976										Annual Mean
		Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
A	<-1.9	15.6	18.8	24.9	13.8	19.4	9.5	17.5	4.6	10.3	7.4	13.1	13.6	14.0
B	-1.9 to -1.7	19.7	20.7	21.3	22.1	27.0	21.7	26.3	17.4	30.5	18.4	25.5	20.6	22.6
C	-1.7 to -1.5	6.9	7.4	5.6	7.7	7.9	9.7	6.0	10.0	5.6	6.7	6.1	5.6	7.1
D	-1.5 to -0.5	23.7	21.5	16.6	35.7	28.7	35.2	21.0	32.7	14.1	27.6	17.5	17.9	24.4
E	-0.5 to +1.5	22.9	23.5	21.0	13.8	15.6	17.0	15.6	17.6	19.5	23.0	20.7	21.2	19.3
F	>1.5	11.2	8.1	10.6	6.9	1.4	6.9	13.6	17.6	20.0	16.9	17.1	21.1	12.6
Total Percentage		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Pasquill-Gifford Stability Class	dT/dz Range[1] for this Stability Class (^{0}C/100m)	1976		1977										Annual Mean
		Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June[5]	July[5]	Aug.[5]	Sept.[5]	Oct.[5]	
A	<-1.9	18.6	12.3	18.0	12.9	12.9	12.6	5.9						13.3
B	-1.9 to -1.7	19.8	20.7	18.5	27.7	21.6	29.6	13.3						21.6
C	-1.7 to -1.5	4.3	7.1	6.8	7.3	7.9	8.1	9.2						7.2
D	-1.5 to -0.5	12.5	16.2	20.9	12.1	30.1	19.0	46.6						22.5
E	-0.5 to +1.5	27.4	23.7	25.4	26.3	19.3	18.1	17.8						22.6
F	>1.5	17.4	20.0	10.4	13.7	8.2	12.6	7.2						12.8
Total Percentage		100.0	100.0	100.0	100.0	100.0	100.0	100.0						100.0

Table 6.3.2-6 (Continued)

Pasquill-Gifford Stability Class	dT/dz Range[1] for this Stability Class (°C/100m)	1977		1978										
		Nov.[5]	Dec.[5]	Jan.	Feb.[3]	Mar.[3]	Apr.[5]	May[5]	June[5]	July[3]	Aug.[3]	Sept.[3]	Oct.	Annual Mean
A	<-1.9			0.7	0.3	0.3				0.0	0.2	0.0		
B	-1.9 to -1.7			0.3	2.1	0.5				2.3	6.1	2.6		
C	-1.7 to -1.5			4.4	2.9	1.9				5.9	5.7	2.6		
D	-1.5 to -0.5			52.0	48.0	47.4				43.2	35.6	40.1		
E	-0.5 to +1.5			28.2	32.9	24.8				19.5	22.5	23.5		
F	>1.5			14.4	13.8	25.1				29.1	29.9	31.2		
Total Percentage				100.0	100.0	100.0				100.0	100.0	100.0		

[1] Adjusted for wind speed
[2] Data are suspect and, therefore, not included
[3] Partial data
[4] Averaged from January-October, excluding July
[5] Missing data
[6] Data for July and August not available for this report

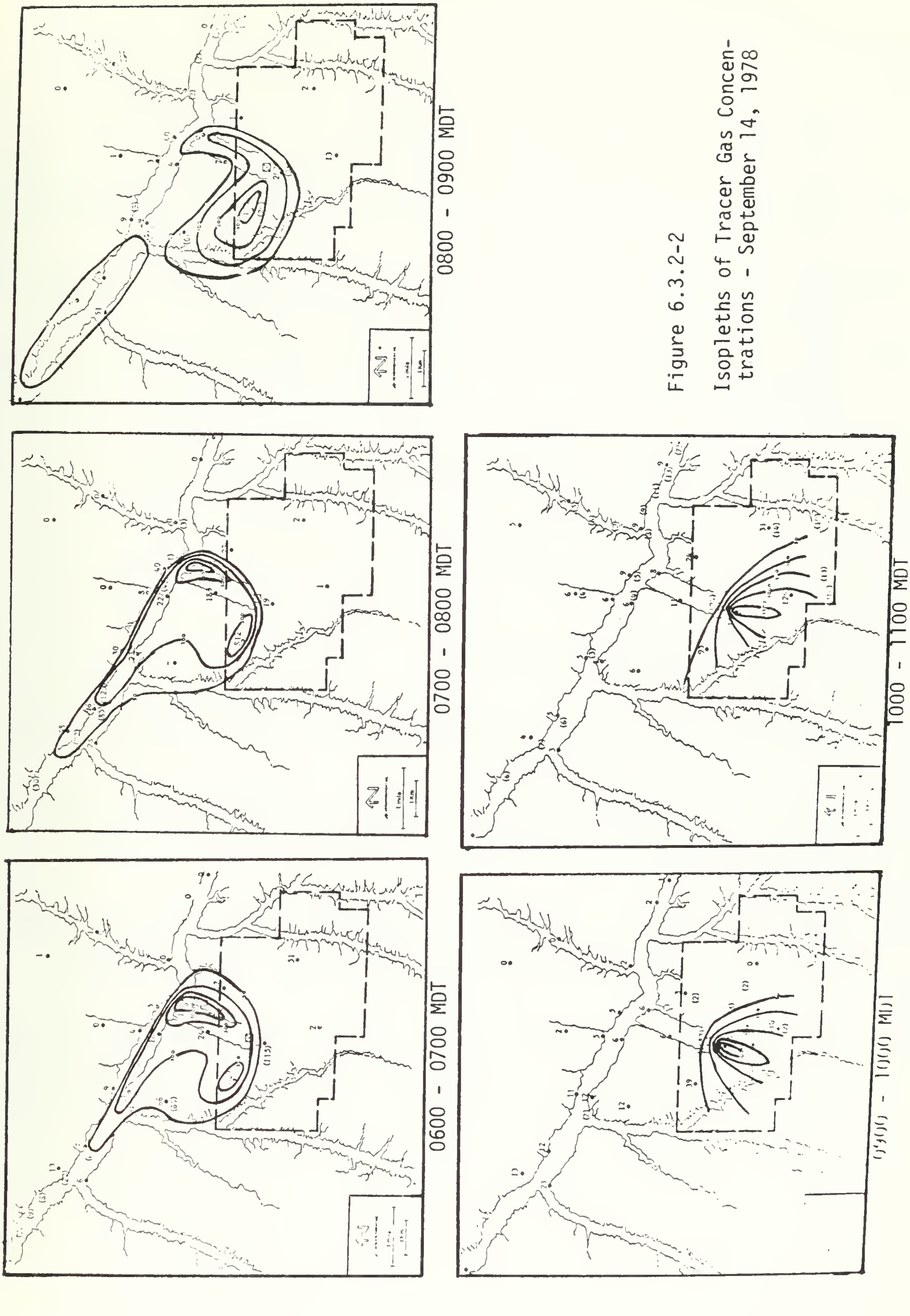


Figure 6.3.2-2

Isopleths of Tracer Gas Concentrations - September 14, 1978

(2) When the plume was released within a layer of very stable air in complex terrain, the plume followed constant potential temperature surfaces, which followed the contour of the ground. It did not just fan out and stay at the same elevation above sea level. In specific, the plume flowed into Piceance Creek and followed the creek downstream rather than traveling across the creek at the level of release and impinging on the surface of the south-facing slope north of Piceance Creek. Contrary to observations of a fanning plume on flat terrain, a fanning plume over tract C-b did get down to the ground surface due to turbulence associated with the shearing effect of the drainage wind.

(3) Fumigation of the plume did not result in high concentrations when measurements were averaged over a period of one-hour or more.

(4) When the surface-based inversion was shallow (as on 15 September), the plume lofted above the inversion and pollutant concentrations at the surface were miniscule.

(5) When the plume was released in a neutral-lapsed layer, the plume centerline followed the contour of ground surface as it traveled downwind.

6.3.2.6 Conclusions

Conclusions supported by the analysis of wind fields data are:

1. Predominant wind direction at the meteorological tower site on Tract is SSW; this has not changed over time.

2. Predominant wind direction in and near Piceance Creek is downstream (from east and southeast) over most of the nightime and early morning. Daytime direction reverses to upstream flow.

3. Wind speed and direction have not changed significantly over the years from baseline through 1978. Spring and summer show higher wind speeds (5-8 meters/sec.) than fall and winter (1-3 meters/sec.) at the 10 meter elevation level.

4. Temperature inversions typically in the Piceance Creek Basin occur in the nighttime with onset about an hour before sunset and breakup next morning several hours after sunrise. Summer inversion heights are the highest (about 400 meters) while winter inversion heights average 150 meters.

5. Temperature inversions occurring in Piceance Creek at elevations above 150 meters will generally extend over the C-b Tract. Typically subtraction of 150 meters from the local inversion heights and mixing heights observed at Piceance Creek Station AB20 is required to obtain heights above the C-b Tract. Very few mixing heights observed at Station AB20 exceed 150 meters.

6. Temperature-Altitude profiles obtained from pibal trajectories indicated inversion heights that were in agreement with acoustic radar inversion heights.

7. Temperature-altitude profiles obtained by either single or double theodolite are adequate for upper air temperature measurements over the C-b Tract.

8. The atmosphere is typically unstable between hours 0900 and 1900. Nighttime is typically stable in summer and fall and neutral in the winter and spring.

9. Tracer test meteorological data confirm the near-surface channelization of winds over the C-b Tract to flow downvalley during early morning under stable conditions.

10. Tracer tests show higher concentrations of pollutant gases can be expected to occur along Piceance Creek to the north and west of the C-b Tract under stable conditions.

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7.0. NOISE

7.1 Introduction and Scope

The environmental noise program conducted during baseline was not required under the lease but was requested by the Area Oil Shale Supervisor. General background noise levels were sought on the Tract and surrounding vicinity prior to Tract development. Monitoring of those levels was reinitiated in February 1978, at the three sites shown in Figure 7.1.1-1 to determine the effects of Tract development on noise levels.

7.2 Environmental Noise

It is to be noted that occupational noise exposure is treated in Chapter 10.0 of this report. Aspects of environmental noise treated here deal with traffic and Tract-generated noise levels.

7.2.1 Traffic Noise

7.2.1.1 Scope and Rationale

The traffic noise study was originated during baseline. Measurements were made one working day per month for approximately one hour at each of 14 locations over a 14-month span starting in September 1975. Measured noise levels (A weightings) above background at two locations along Piceance Creek Road were always made in the presence of passing vehicles. The noise analysis contained in the final baseline report indicated an average level at a station on Piceance Creek Road near Hunter Creek to be 53dbA which was exceeded ten percent of the time.

On the basis of low noise levels existing during baseline as indicated in the final baseline report, it was felt that continued discrete measurements were warranted at only two of the original 14 locations. Stations NA02 and NA09 are located to indicate traffic noise levels associated with development.

7.2.1.2 Objectives

To measure potential increases in traffic noise levels due to development.

7.2.1.3 Experimental Design

Discrete traffic noise measurements are made one day per week during the morning shift change in the presence of passing vehicles at Stations NA02 and NA09 (Figure 7.1.1-1) along Piceance Creek Road and on the access road at the Tract boundary, respectively. The General Radio 1565 Sound Level Meter (SLM) is used to measure peak noise levels at A weightings. Background levels are obtained the same day at A, B, and C weightings.

FIGURE 7.1.1-1

NOISE ENVIRONMENTAL MONITORING NETWORK

● TRAFFIC NOISE STATION - SHIFT CHANGE - 1 DAY/ WEEK

■ TRACT NOISE SURVEILLANCE - CONTINUOUS - EVERY 6th DAY

7.2.1.4 Method of Analysis

At each of the two stations, peak noise levels measured weekly are averaged once each month.

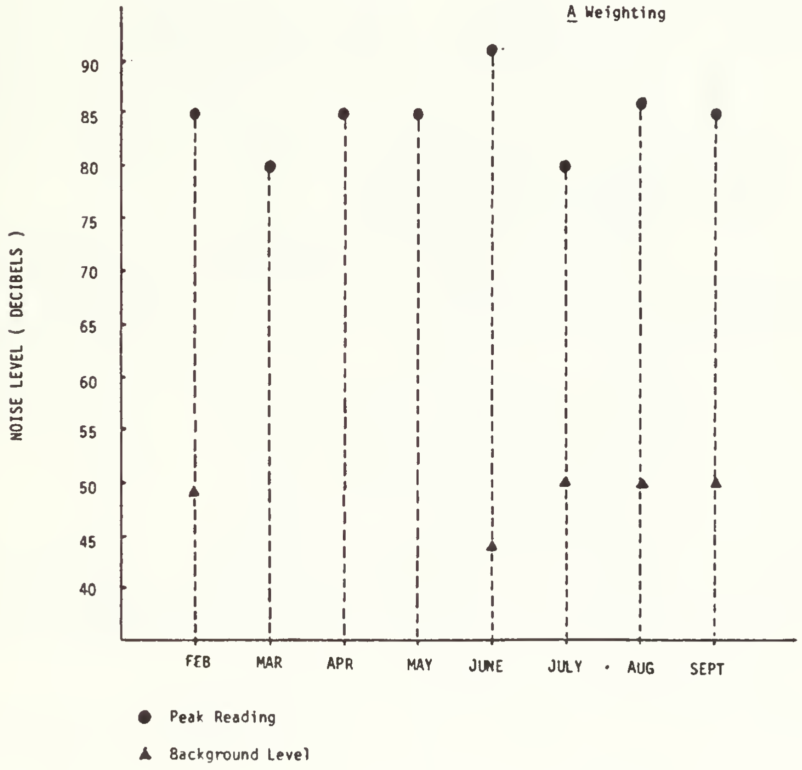
7.2.1.5 Results and Discussion

Figure 7.2.1-1 shows a time plot of peak traffic noise levels and background levels for the C-b Tract. The highest noise level of 91 dbA occurred on June 30, 1978 at Station NA02 from a passing semi-trailer truck; the background at that time was 44 dbA. The peak noise level indicated in the final baseline report was 83 dbA from a road scraper in July 1976. Seventy-five percent of the 1978 monthly peaks exceeded this level; on the average, the 1978 monthly peaks are 9 db higher than those during baseline.

FIGURE 7.2.1-1

TRACT C-b PEAK TRAFFIC NOISE READINGS

(1978)



7.2.1.6 Conclusions

Monthly peak noise levels and background levels during 1978 exceed those of the baseline period by an average of 9 dbA. It is felt that this increase is probably development related.

7.2.2 Tract Noise

7.2.2.1 Scope and Rationale

During the ancillary phase of development nearly all activity occurs near the northern boundary of the Tract. Thus a noise monitoring site in the vicinity of operations is most appropriate for monitoring noise levels on Tract due to ancillary development.

7.2.2.2 Objectives

The objectives of the Tract noise study are 1) to evaluate increases in Tract noise due to Tract development, and 2) to demonstrate compliance with State noise regulations.

State noise standards for an industrial zone are as follows in terms of maximum allowable noise levels:

Steady:	80 db(A)	7am to next 7pm
	75 db(A)	7pm to next 7am
15 min. in any one hour	90 db(A)	7am to next 7pm
Periodic, impulsive,	75 db(A)	7am to next 7pm
shrill	70 db(A)	7pm to next 7am

They apply within 25 feet of the property line (Tract boundary).

7.2.2.3 Experimental Design

Continuous noise measurements are made at Station NB15 (Figure 7.1.1-1) on the northern boundary of the Tract for 24 hours every sixth day. The sensor recording system consists of the following B&K instruments:

Model 2203	Precision Sound Level (SLM) with 0.5" microphone
Model 4230	Portable Acoustic Calibrator
Model UA 0393	Microphone Rain Cover
Model UA 0381	Wind Screen with Spikes
Model UA 0308	0.5" Dehumidifier
Model 2306	Portable Graphic Level Recorder

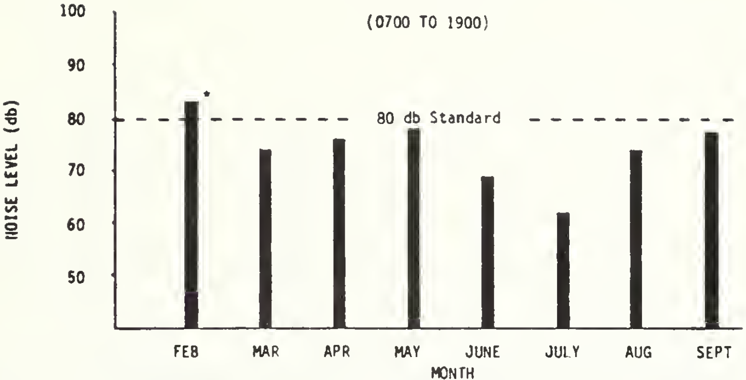
In this model the SLM is coupled to the battery-operated linear recorder for 24-hours of unattended all-weather operations at an A-weighting.

The SLM is calibrated before each day's use with its portable acoustic calibrator to ± 0.25 db accuracy at 93.6 db, 1 kHz. The linear recorder for a range is calibrated before and after each day's use. Thus any drifts are readily apparent. Time references are annotated before and after operation.

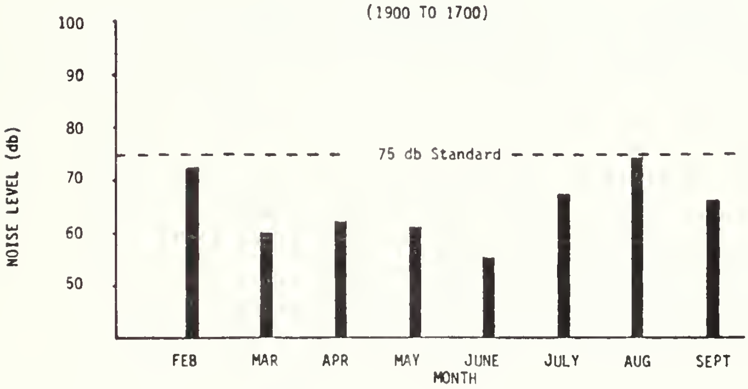
FIGURE 7.2.2-1

TRACT C-b NOISE STANDARDS COMPLIANCE

SITE NB15 - 12 HOUR PEAK NOISE READINGS (db) FOR 1978



* On 2-13-78 for 0700 to 1900 peak did not exceed 90 db for 15 minutes in any hour.



7.2.2.4 Method of Analysis

Twelve-hour peaks (7am-7pm and 7pm-7am) are reported along with averages and background levels for each day of observations. Figure 7.2.2-1 presents the peak 12-hour Tract noise levels.

7.2.2.5 Results and Discussion

The peak Tract noise level reading of 83 decibels occurred on the first day of monitoring in February 1978; that peak did not exceed 90 dbA for 15 minutes in any hour. All other readings through September 1978 at site NB15 were below 80 dbA from 0700 to 1900 and below 75 dbA from 1900 to 0700. The average decibel level from 0700 to 1900 was below 45 dbA while the average from 1900-0700 was below 42 dbA.

7.2.2.6 Conclusions

1. Noise levels in the Tract area due to development activities have, for the most part, been low. Average levels of neither 12-hour period appear to have increased significantly during the study period.

2. Compliance with State noise standards for an industrial zone was achieved.

7.3 Overall Conclusions

1. Peak noise levels and background levels along the Tract boundary increased by an average of 9 dbA since the baseline period.

2. Average noise levels on Tract for the two 12-hour periods do not appear to have increased significantly due to development activities.

3. Compliance with State noise standards for an industrial zone was achieved.

8.0 BIOLOGY

8.1 Introduction and Scope

The goal of the biological monitoring program is to continue evaluation of biotic conditions and identify interactions with abiotic conditions in the Tract C-b ecological systems. The majority of monitoring parameters are those that provide information relative to early warning signals of change. The use of control and development sites permits the monitoring of long-term trends at affected and non-affected sites, and the analysis of any corresponding differences developing over time at these sites.

8.2 Big Game-Deer

Big game refers primarily to mule deer, since they are the only large mammals common to the C-b area. Intensive studies of mule deer are justified since deer are a major herbivore of ecological importance, and a game species of economic importance. In addition, they are vulnerable to impact from development activities, road kill, and increased hunting pressure. Study transects and sample sizes are based on adequate samples obtained during baseline.

Monitoring of mule deer attempts to show the significance of Tract C-b to their survival. This is accomplished through the following variables: 1) deer-use days, 2) distribution and migration, 3) road kills, 4) mortality, and 5) age class.

8.2.1 Deer Day Use

8.2.1.1 Scope and Rationale

Pellet group counts were conducted on 27 permanent transects on or near Tract C-b to evaluate the deer use in the area.

8.2.1.2 Objectives

The objectives were to use deer pellet group data to check to see if significant differences existed among the sizes and distributions of local deer concentrations at selected sites on a year-to-year basis.

8.2.1.3 Experimental Design

Two habitat types were sampled; pinyon-juniper woodland and chained pinyon-juniper. Fifteen transects were located in the chained habitat type and twelve transects were located in the woodland. These same transects were used for lagomorph and browse utilization and production transects. Each transect consisted of 20 plots, with plots being 15 meters apart. Locations of the transects were well within the boundaries of the habitat type (avoiding habitat edges), and were positioned such that comparisons could be made of development vs. control areas, i.e., oil shale vs. non-oil shale effects. Some of these transects were placed to the north and west of the Tract to detect shifts in distribution due to development-related activities. There were 9 developmental and 18 control transects. Stations using the symbol BA are identified on the jacket map. Data concerning deer pellet-group distributions and densities were obtained by counting pellet-groups along these twenty-seven transects. Pellets were swept from plots during the fall of 1977 and counts were made the following spring.

Fifteen new transects were added to the original twelve that were established during the interim-monitoring program: nine in the chained rangeland habitat on Big Jimmy ridge; and six in the pinyon-juniper habitat north of Piceance Creek. Both of these locations are just outside Tract C-b boundaries.

The pellet-group data obtained from all twenty-seven transects are here considered to be baseline data. Construction operations, which began during the past year, are assumed to have caused no appreciable impacts to deer in those areas where transects are located. Transect BA16, however, is near the main access road that was constructed during the spring of 1978. Construction activities along this right-of-way have influenced pellet count data on one or two of the 20 plots that make up the transect, but examination of these data do not suggest this to be the case.

Since future deer pellet counts are likely to be markedly influenced at certain transect locations due to development, the relative differences which exist among the twenty-seven transects at this final baseline stage are of considerable importance. This, and all previous baseline information on pellet-group distributions represent the final pattern, or array of data points, from which future departures of a significant nature will be looked upon as due to development-related impacts.

8.2.1.4 Method of Analysis

Results were evaluated using single factor analysis of variance (ANOVA) and Student-Newman-Keuls (SNK) multiple range testing.

8.2.1.5 Results and Discussion

The results of pellet-group counts for the 1977-78 period (Tables A8.2.1-1a to 1d) are presented as individual estimates for density for each of the twenty-seven transects and as combined values for clusters of transects. With regard to the grouping of certain transects, it may be appropriate in future evaluations to combine different clusters because of development activities in locations not anticipated at this time. Some amount of combining will probably always be needed in order to achieve sampling adequacy.

The apparent differences in the three sets of combined values for the chained rangeland habitat (Tables A8.2.1-1a and 1c) were evaluated using single factor analysis of variance (ANOVA) and Student-Newman-Keuls (SNK) multiple range testing. Significant differences (at the 95 percent level) were found to exist between the two combined values for the chained pinyon-juniper transects on the tract, namely, the mean density estimates of 288 vs. 437 pellet-groups per acre (transects BA17, 18, 25 vs. transects BA20, 21, 25)(Table A8.2.1-1c); and between the combined value of 398 per acre obtained for Big Jimmy ridge (Table

A8.2.1-1c) and the 288 mean value for the tract (Table A8.2.1-1a). The 437 and 398 values obtained for the tract and for Big Jimmy ridge respectively were not found to be significantly different. Differences in pellet-group densities among the four combined values for the pinyon-juniper habitat (Tables A8.2.1-1b and A8.2.1-1d) were also subjected to ANOVA and SNK testing. All combinations of three values (105, 357, and 238 pellet-groups per acre) (transects BA10-12; BA13-15, and BA19, 26, 27) were found to be significantly different at the 95 percent level. Only the differences between the two combined values for the tract (238 and 198) (transects BA16, 22, 24) were not found to be significant.

In terms of trend evaluations it is important to note that the highest pellet-group density estimates obtained over the past two years occurred on transects BA20 and BA21, which are located near Sorghum Gulch. This consistency is demonstrated in Figure 8.2.1-1, which also shows a consistent pattern of relative densities for all transects when comparing the two years. This apparent correlation is, in fact, statistically significant ($\gamma=0.86$, $P=0.001$).

The decline in the density estimates during the second year, 1977-78, represents a mean drop of 48 percent. This should not be taken as suggesting there were 48 percent fewer deer during the 1977-78 period, since an investigator bias is known to have existed during the 1976-77 period. This bias, however, is believed to have uniformly inflated the 1976-77 estimates, and not to have affected relative differences among transects.

Direct comparisons of pellet-group data over the past two years with data from the first two years of baseline study (C-b Final Environmental Baseline Report 1974-76) is not possible, since transect locations were changed for the development monitoring program.

Data from pellet-group distribution and density studies on transect locations which have been operative over the past two years have indicated very similar patterns of habitat use.

8.2.2 Distribution and Migration

8.2.2.1 Scope and Rationale

Deer road counts have proven useful for showing deer distributions along the Piceance Creek highway. The structured road count observations are repeatable, and provide a means of quantifying changes in relative abundance and distribution.

8.2.2.2 Objectives

The main objectives were to determine the seasonal and year-to-year movement patterns of deer.

8.2.2.3 Experimental Design

Weekly sampling was obtained beginning in mid-September and ending in May. The sample area was the 41-mile stretch of Highway 64. Times of migration were based on the occurrence and disappearance of deer in the meadows. Counts were made from a vehicle driving approximately 30 m.p.h. The counts were started one hour ± 15 minutes before dusk and the direction of travel was altered

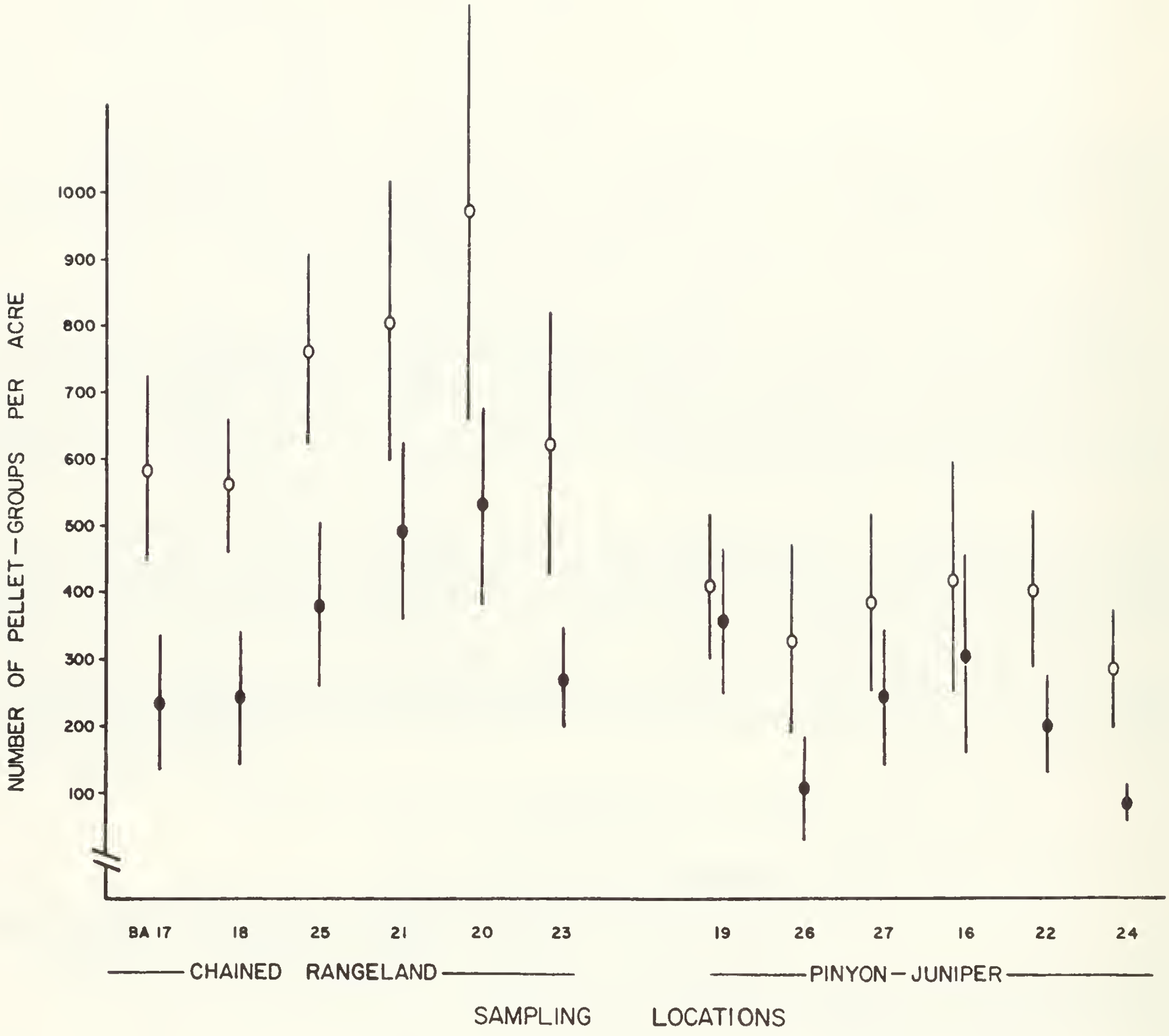


Fig. 8.2.1-1 Trends in pellet-group densities. Data shown are means ± 95 percent confidence intervals. Open circles are 1976-77 data; closed circles are 1977-78 data. Although pellet-group densities are lower the second year, the pattern of habitat use is significantly correlated (Y=0.86; P=0.001).

for consecutive (weekly) counts. The number of deer observed in each mile interval was recorded according to feeding locations on the slopes or in the meadows.

8.2.2.4 Method of Analysis

Histograms were prepared and compared to past years' data. The log-likelihood G test or other applicable nonparametric tests will be used if changes in observed distributions occur.

8.2.2.5 Results and Discussion

Twenty-nine road counts were conducted from September 1977 to May 1978 (Table A8.2.2-1). The length of road traveled during this period of investigation (41 miles) was expanded by six miles over the previous three years of study to include the section of road from Little Hills to the White River. A summary of the deer road counts is presented in Figure 8.2.2-1.

Due to seasonal differences in habitat use by deer and changes in vulnerability to road kill, Table A8.2.2-1 separates road count data into fall, winter, and spring periods. Locations along the road where fall road counts were particularly high include virtually the entire distance from mile 14 (Oldland's ranch) to mile 31 (Burk's ranch). From December through January, deer were not nearly as abundant near the road, although mile 22 (near Hunter Creek) retained a high count. During late winter and early spring, road counts were generally high over the entire 41 mile length of road. Very high counts occurred immediately west of the tract, between mile 20 (the main entrance road to Tract C-b) and mile 25 (near Rock School).

Trends in the number of deer observed along the six miles of road which approximately borders Tract C-b on the north will provide one means of evaluating impacts to deer due to construction and operation of the oil facility. It seems likely that disturbances and habitat loss on tract will eventually result in fewer deer observed especially from mile 17 to mile 20. No indications of this were apparent this past year, however.

The 1977 fall influx of deer into the Tract C-b area occurred during mid-October. Apparently during mid April of 1978 deer began to move to higher summer range. This pattern is similar to what was observed over the past three years of baseline study. As in previous years (1974,'75,'76) the majority of deer observed during the October deer counts were concentrated in the meadows between mile markers #15 to 20. In the spring, with the exception of high concentrations between mile 15 - 20, the deer have been fairly evenly distributed along the entire Piceance Creek highway. This was not the case in 1977. Large concentrations of deer were observed at the Rio Blanco Store end of the road. These slopes were free of snow before other south-facing slopes which may have attracted the deer. Deer distribution and migration will continue to be monitored and possible trends identified.

8.2.3 Roadkills

8.2.3.1 Scope and Rationale

Mule deer roadkill data were collected weekly to obtain

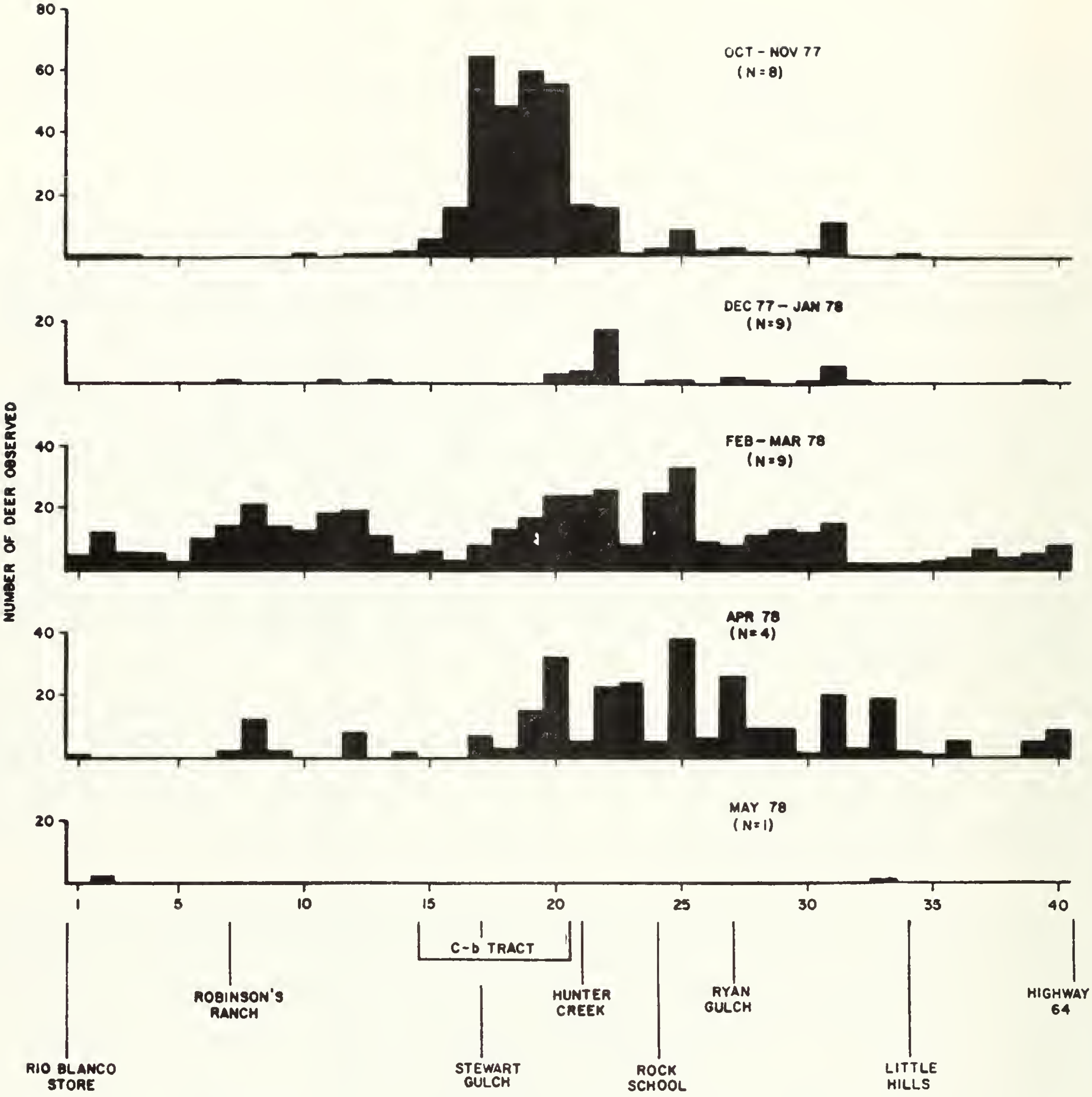


Fig. 8.2.2-1 — Summary of deer road counts for 1977-78. Heights of bars are means; sample size (N) are the number of road counts for the period.

information on the number of deer killed each year along the Piceance Creek highway.

8.2.3.2 Objectives

Roadkill data were collected to obtain an accurate fatality estimate and identify problem areas so mitigative measures could be taken, if necessary.

8.2.3.3 Experimental Design

Weekly roadkill data were collected from September 1977 into May 1978 at the same stations used for the deer road-count study. Dead deer were aged, sexed, and tagged. In addition, one ear was removed to insure that double counting did not occur.

8.2.3.4 Method of Analysis

When several years of data has been collected, monthly time series tabulations and non-parametric tests such as the log-likelihood G Test (Sokal & Rohlf 1967) will be used.

8.2.3.5 Results and Discussion

Roadkill data for 1977-1978 are presented in Table 8.2.3-1. The total roadkill along the Piceance Creek highway was 125 deer and one elk. This figure was derived by combining the information gathered by Division of Wildlife and Tract C-b personnel. At present, only general observations can be made. Most of the roadkills occurred in the fall and spring. This concurs with the deer movements; many deer are close to the highway during these times. Approximately 50% of the deer killed were fawns. Roadkill information will continue to be monitored closely to establish trends and possible mitigative measures. Cumulative roadkill approximates 1% of the total sited at these stations, noting that the same deer may be seen or recounted on subsequent weeks.

8.2.4 Mortality

8.2.4.1 Scope and Rationale

Baseline studies have shown winter kills to be largely restricted to two habitat types, lateral draws and bottomland sagebrush. Checking these areas each spring has helped in observing changes in the relative magnitude of deer mortality.

8.2.4.2 Objectives

The purpose of this study is to determine deer mortality in selected gulches.

8.2.4.3 Experimental Design

Sampling was done in the spring in 10 plots located in lateral draws and sagebrush gulches (Map in jacket). All dead deer were aged, sexed, and tagged with a metal tag stamped with the study year to date the deer carcasses. Either the skull or pelvic girdle was required to be with the

Table 8.2.3-1

MULE DEER ROADKILL SUMMARY (FALL 1977 TO SPRING 1978)

MILE INTERVAL	OCT.			NOV.			DEC.					JAN.				FEB.				MAR.					APR.				MAY	MILE INTERVAL
	24	27	28	3	10	17	1	8	15	22	29	5	12	19	25	3	9	16	23	2	9	16	23	30	6	13	20	27	4	
0 Rio Blanco Store																														0
1																														1
2			1		1																									2
3																														3
4																														4
5																			1											5
6																														6
7	1					1								1				1	4	3			1							7
8																				1										8
9					1																		1							9
10																*			2							1				10
11		1																			1		1							11
12		1																												12
13																													1	13
14																														14
15															1						1	1								15
16				1																					1					16
17		1		1	1								1			1				2				1						17
18	1																							1		1	1		1	18
19				1														1	1				1	1						19
20	1	1				1						1								1					1	1				20
21			1			1	1	1																	1	1				21
22					1																		1							22
23												1																		23
24 Rock School				1		1																								24
25																	1													25
26																														26
27												1																		27
28																			1											28
29				1																1			1							29
30																														30
31						3						2	1																	31
32																					2									32
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34													1				1			1										34
35																										1				35
36													1																	36
37														2									1			1				37
38																														38
39															1			1	2											39
40													2								1									40
41 White River City																				1		1								41
TOTAL	3	4	2	5	4	7	1	1	0	0	0	5	6	3	2	2	2	3	11	10	5	2	7	3	3	6	1	0	2	

NOTE: Total Kill was 125 Deer. One Elk killed. This Figure was derived from combining DOW data with C-b data.

carcass before it was counted, i.e. just a leg or other bones did not constitute a carcass.

8.2.4.4 Method of Analysis

Non-parametric tests such as the log-likelihood G Test (Sokal & Rohlf 1967) will be used when several years of data have been collected on these mortality plots. Tabular presentations are used here.

8.2.4.5 Results and Conclusions

A comparison of deer mortality is presented in Table 8.2.4-1. Since several new draws have been added to the study, detailed analysis cannot be done. Possibly due to the mild winter, there were fewer dead deer per hectare than in previous years. Fawns comprised 80% of deer mortality found this year.

8.2.5 Age Class

8.2.5.1 Scope and Rationale

Estimating the composition of the deer herd in the fall facilitates evaluation of the magnitude of fawn mortality that has occurred during the spring and summer while deer were on summer range. Estimates taken in spring permit evaluation of fawn mortality that occurred while deer were on winter range in the C-b area.

8.2.5.2 Objectives

The main objective of the age class study was to determine fawn-to-adult ratios in the fall and spring.

8.2.5.3 Experimental Design

Sampling occurred in the fall and the spring. Sampling locations were situated in meadows immediately north of the Tract and major drainages within the study area. Counts were restricted to within five miles either side of Tract C-b and were conducted in November and in May. The observations took place during times of potential heavy concentrations. Animals were recorded as adults, fawns, or bucks. No attempt was made to recognize yearlings, and bucks were counted only when antlers were visible (otherwise, they were recorded as adults). The number of points on an antlered buck were noted when easily and quickly counted.

8.2.5.4 Method of Analysis

When sufficient data become available for year-to-year proportions to be established the T-test for proportions will be used to test the null hypothesis at the 0.10 level of significance. Data from this program, combined with data from the other Tract deer studies, tagged deer from the Division of Wildlife, and the roadkill simulation model will be used to further understand the dynamics of the deer herd on and surrounding Tract C-b. Interrelationships with other ecosystem elements may be evaluated through use of multiple time series techniques.

TABLE 8.2.4-1 DEER MORTALITY RESULTS

YEAR	HABITAT TYPE	NO. OF CARCASSES FOUND	HECTARES SAMPLED (ACRES)	CARCASSES/ HECTARE (ACRES)
1977-78	Sagebrush - Lateral draw	25	70.5 (174)	.355 (.144)
1976-77	Interim Monitoring Period - No Sampling			
1975-76	Lateral draws	8	7.25 (18)	1.10 (0.44)
1974-75	Lateral draws	11	7.25 (18)	1.52 (0.61)

8.2.5.5 Results and Conclusions

An estimate of the age-class composition of deer wintering near Tract C-b is given in Table 8.2.5-1. Results differ markedly from the previous three years in that the ratio of fawns to adults was higher in the spring than in the previous fall. One would have expected proportionately fewer fawns in the spring due to higher winter fawn mortality.

8.3 Medium-Sized Mammals

The medium-sized mammals are restricted to several species which are important within the Tract C-b ecosystem, coyotes and lagomorphs (cottontails and jackrabbits). Monitoring these animal groups will show important trends which will contribute to the understanding of predator and prey-species in the Tract C-b ecosystem.

8.3.1 Coyote Abundance

8.3.1.1 Scope and Rationale

Coyotes are of ecological significance because they are a major predator on Tract C-b. They are of political and economic interest to the public with both strongly negative and positive supporters. Collection of scent post data is important in understanding the C-b ecosystem, particularly predator/prey relationships.

8.3.1.2 Objectives

The objective of conducting coyote scent post surveys was to determine relative abundance of coyotes on or near the tract.

8.3.1.3 Experimental Design

The coyote scent post survey is based on the Linhard and Knowlton Method (1975), which is currently being used by the U.S. Fish and Wildlife Service. Sampling was done in September along 15 miles of road segments on or near the Tract. Scent stations along the transects were checked for the presence of tracks. Track surveys also yielded information on other species of mammals which may have inhabited or occasionally passed through the Tract. The stations were checked the morning following the setting of the traps.

8.3.1.4 Method of Analysis

A relative index of abundance was calculated as a visit frequency. Professional judgment also will be used to determine significant differences over time.

8.3.1.5 Results and Conclusions

Results of the September 1978 coyote scent stations survey (Table 8.3.1-1) are considerably lower than 1977 results. Indices of 50 and 130 were obtained for 1978 and 1977 respectively. Reasons for the apparent decline are unknown. The only removal of coyotes of which we

Table 8.2.5-1
Age class composition of mule deer wintering near Tract C-b

Date	Fawns	Does	Bucks	Adults	Fawns/ 100 Does	Bucks/ 100 Does	Fawns/ 100 Adults
15-23 Nov. 1977	85	107	28	135	79.4	26.2	63.0
4-7 Apr. 1978	68			104			65.0

Table 8.3.1-1
Results of coyote scent station survey, 1978.

Line	Location	No. of stations	No. of visits
1	Big Jimmy	25	2
2	SG-9	10	0
3	Scandard	10	0
4	SG-15	10	2
5	SG-11	10	0
6	Stewart ridge	15	0
7	Stewart valley	10	1
8	Bailey ridge	10	0

$$\text{Index of abundance} = \frac{\text{No. of visits}}{\text{No.of stations}} \times 1000 = 50$$

are aware took place in October 1978 when 42 coyotes were trapped on the Oldland property north and east of Tract C-b.

No new species of medium-sized mammals were identified during the past year of field study.

8.3.2 Lagomorphs

8.3.2.1 Scope and Rationale

Cottontails and jackrabbits provide an important prey base for raptorial birds and coyotes. The cottontail is classified as a game species, but presently it is of little economic value in the vicinity of Tract C-b; however, at some future date its status could change. The lagomorph population estimates are based on relative abundance data collected from strip transects.

8.3.2.2 Objectives

The objectives were to determine the relative abundance of lagomorphs on or near Tract C-b.

8.3.2.3 Experimental Design

Relative abundance of cottontail rabbits was established along the twenty-seven transects used for mule deer pellet-group counts. The study was expanded to include Big Jimmy Ridge. The number of plots sampled were 20 plots/transect.

8.3.2.4 Method of Analysis

A relative index of abundance was calculated as a visit frequency.

8.3.2.5 Results and Conclusions

The results of this study are considered to be most valuable for comparing relative differences among years, rather than for comparisons of differences among transects. Trend evaluations are not feasible at this time, however, since data for the twenty-seven transects being used are only available for the 1977-78 period. (Table 8.3.2-1). General observations between this year's and previous year's data show that cottontail abundance was slightly higher in the pinyon-juniper woodlands compared to chained pinyon-juniper. Field observations this fall tended to show that the cottontail population was higher in fall 1978 than in fall 1977.

8.4 Small Mammals

8.4.1 Species Composition and Abundance

8.4.1.1 Scope and Rationale

Small mammals are important to monitor because they are both a prey base for predators and a major primary consumer. Monitoring

Table 8.3.2-1
Relative abundance of cottontail rabbits, 1977-78. Each transect consists of twenty 0.01 acre plots.

Transect		Habitat and location	Relative abundance*
Monitoring notation	Baseline notation		
BA 01	CH-C-12	Chained, Big Jimmy	55
BA 02	CH-C-11	"	15
BA 03	CH-C-10	"	30
BA 04	CH-C-9	"	45
BA 05	CH-C-8	"	90
BA 06	CH-C-7	"	55
BA 07	CH-C-6	"	80
BA 08	CH-C-5	"	65
BA 09	CH-C-4	"	80
BA 17	CH-C-1	Chained, Tract	35
BA 18	CH-C-2	"	45
BA 25	CH-C-3	"	60
BA 21	CH-T-1	"	70
BA 20	CH-T-2	"	35
BA 23	CH-T-3	"	42
BA 19	PJ-C-1	Pinyon-juniper, Tract	40
BA 26	PJ-C-2	"	70
BA 27	PJ-C-3	"	90
BA 16	PJ-T-1	"	35
BA 22	PJ-T-2	"	58
BA 24	PJ-T-3	"	35
BA 13	PJ-C-4	P-J, north of Piceance Crk.	85
BA 14	PJ-C-5	"	60
BA 15	PJ-C-6	"	15
BA 10	PJ-T-4	"	75
BA 11	PJ-T-5	"	75
BA 12	PJ-T-6	"	75

* Relative abundance is calculated as a percent frequency ((No. of plots with fresh pellets present ÷ No. of plots sampled)x 100).

changes in selected small mammal parameters will aid in assessing potential effects of pollutants before populations of larger animals are greatly affected.

8.4.1.2 Objectives

The objectives of monitoring small mammals on Tract C-b were to determine small mammal species composition, reproductive conditions, age classes and relative abundances and to see how the development of Tract C-b is affecting this population as manifested by these parameters.

8.4.1.3 Experimental Design

Small mammal live trapping was conducted in three habitat types: pinyon-juniper woodland, chained rangeland, and agricultural meadow. The agricultural meadow was divided into control and experimental (hereafter referred to as "development") plots. Linear transects consisting of 25 traps spaced at 10m were placed as follows: four transects in each of the two meadow locations; two transects each in the pinyon-juniper and chained rangeland habitats. Trapping occurred for three consecutive nights (omitting rainy nights) during June and August. After each night all traps were repositioned using new transect locations.

8.4.1.4 Method of Analysis

Indices of relative abundance were calculated to allow comparisons between the data.

8.4.1.5 Results and Conclusions

Small mammal trapping results for the June and August periods (Table 8.4.1-1) are presented as indices of relative abundance in order that differences can be directly compared. Future trend evaluations will continue to use these indices to facilitate descriptions of yearly fluctuations and changes suggestive of impacts.

The small mammal results obtained this past year are in no way unusual compared to prior studies conducted during the first two years of baseline study. The deer mouse (*Peromyscus maniculatus*) was, as in previous years, the most abundant small mammal species in the habitat types trapped on Tract C-b. Of most interest in subsequent years will be changes in species diversity and relative abundance between control and development locations in the agricultural meadows.

8.5 Avifauna

A wide variety of birds exist on Tract C-b and the surrounding area. Avifauna were monitored to determine potential effects on habitat disturbance.

8.5.1 Songbird Relative Abundance and Species Composition

8.5.1.1 Scope and Rationale

Songbirds were monitored during their breeding season to determine potential development effects. It is anticipated that habitat

Table 8.4.1-1

Relative abundance of small mammals, 1978.*

Common name Scientific name	TRAPPING LOCATION							
	Meadow, control plot		Meadow, developmental plot		Pinyon-juniper		Chained rangeland	
	JUN	AUG	JUN	AUG	JUN	AUG	JUN	AUG
Deer mouse *Peromyscus maniculatus*	3.7	29.7	4.0	22.3	18.7	30.7	24.7	28.7
Montane vole *Microtus montanus*	0	1.3	0.3	0.7	0	0	0	0
Western jumping mouse *Zapus princeps*	0	1.3	0.3	0.7	0	0	0	0
Least chipmunk *Eutamias minimus*	0	0	0	0.3	0.7	1.3	8.7	12.0
Uinta chipmunk *Eutamias umbrinus*	0	0	0	0	2.7	0.7	0.7	1.3
Golden-mantled ground squirrel *Spermophilus lateralis*	0	0	0	0.7	0	0	1.3	0
Bushy-tailed woodrat *Neotoma cinerea*	0	0	0	0	0	0	0	0.7

* Relative abundance is calculated as a percent frequency ((No. of captures ÷ number of trap-nights) x 100). In the meadow locations, 100 traps were set for three nights (300 trap-nights); in the pinyon-juniper and chained locations, 50 traps each were set for three nights (150 trap-nights).

disturbance and increased human activity may affect population densities and relative abundance of the more prominent species. Certain species may be more affected by man-made impacts than others.

8.5.1.2 Objectives

The objectives were to monitor population densities, species abundance and diversity of the songbirds in the area and compare this information to past years data.

8.5.1.3 Experimental Design

Monitoring of avifauna for 1978 occurred between May 23, 1978 and June 28, 1978. Monitoring efforts were consistent with previous interim sample periods in that two transects in Pinyon-juniper woodland and two transects in chained Pinyon-juniper rangeland were censused. Each transect was sampled in quadruplicate; twice at the beginning of the breeding season, once in the middle and once at the end of the season. One transect in each habitat type (Transects 1 and 4) is located in an area which will not be disturbed by shale oil development. The remaining two transects (2, 3) are sample areas within each habitat where some disturbance from oil shale development is anticipated. All transects are 800 meters long and are permanently marked with steel rebar stakes and flagging. The method employed for censusing was the strip transect method as described by Emlen (1971) with slight modifications. This method provides data from which quantitative estimates of density of songbird and songbird-like species can be calculated.

8.5.1.4 Methods of Analysis

The population density estimates for species observed on strip transects were determined by one of the three methods described by Emlen (1971) which depended on the conspicuousness of the species to the observer. Since the validity of any of these methods varied for different species, professional judgment, based on experience with the conspicuousness of various species within different habitats during different seasons, was used in selecting the best density estimator. The Shannon-Weiner calculations (Pielou 1966) were used to compute indices of species diversity (H'), maximum diversity (H'max) and equitability (J) for each habitat sampled by strip transect procedures. Symbols are defined in Table 8.5.1-1. After three years of monitoring, statistical analysis of variance will be applied to replicated census data from each of the plots to estimate variations within, as well as between sampling plots.

8.5.1.5 Results and Conclusions

Table 8.5.1-1 presents diversity indices calculated for each transect. As with previous sample periods, the pinyon-juniper woodland exhibited greater avain diversity than the chained pinyon-juniper rangeland. Brewer's sparrows and green-tailed towhees were the most abundant species in chained pinyon-juniper rangeland, while the bustit, black-throated gray warbler were common in pinyon-juniper woodland.

Table A8.5.1-1 in the appendix lists bird species observed during the spring 1978 census. Included in Table A8.5.1-1 are species that were observed but were not included in the quantitative analysis because they were not observed within a strip census corridor or because specific habits of species, such as

TABLE 8.5.1-1 AVIFAUNA

SHANNON-WIENER DIVERSITY INDICES (H'), UNBIASED ESTIMATES OF H' (E(H')), VARIANCE OF H' (var(H')), MAXIMUM EXPECTED VALUE OF H' (H'(max)), AND EQUITABILITY (J), FOR AVIFAUNA TRANSECTS AT TRACT C-b DURING SPRING SAMPLE PERIOD, 1977, 1978.

TRANSECT	VEGETATION TYPE	YEAR	H'	E(H')	var(H')	H'(max)	J
1	Chained Pinyon-Juniper Rangeland - Control	1977	1.494	1.454	0.009	2.079	0.718
		1978	1.665	1.634	0.007	2.398	0.694
2	Pinyon-Juniper Woodland - Developmental	1977	2.469	2.432	0.003	2.890	0.854
		1978	2.398	2.350	0.004	2.708	0.886
3	Chained Pinyon-Juniper Woodland - Developmental	1977	1.950	1.895	0.004	2.197	0.888
		1978	1.885	1.868	0.003	2.398	0.786
4	Pinyon-Juniper Woodland - Control	1977	2.740	2.709	0.001	2.944	0.931
		1978	2.545	2.522	0.002	2.890	0.881

DEFINITIONS FOR SHANNON-WIENER CALCULATION VARIABLES

H'=Diversity. H' is an estimate of the diversity of the total population of individuals in a species pool. It is dependent on both the number of species in a collection and the relative abundance of each species (or evenness). Diversity can be thought of as measuring the uncertainty of predicting the species of an individual drawn at random from the entire population of individuals of several species. This uncertainty, or diversity, of a community can be increased either by increasing the number of species or by evening out the distribution of individuals among species. An H' value of zero is obtained when all individuals belong to the same species. Maximum values are obtained when all individuals belong to different species.

E (H') = The expected or unbiased estimate of H'. An estimate of diversity (H') corrected for bias associated with sample size.

Var (H') = Variance of H'. Variance is a measure of dispersion. It is defined to be the average of the square of the deviations of a set of measurements about their mean.

H' (max) = The maximum value of H'. An estimate of maximum possible species diversity for a given number of species and individuals.

J = Equitabliity or Evenness. The distribution of individuals among species is referred to as equitability. As discussed under diversity, evenness is a component of diversity. Large values of J are indicative of a rather even distribution of densities among species, while low values suggest dominance by a few species. J is expressed as the ratio of H' over H' max (H'/H'max).

red-tailed hawk and common raven, rendered them unsuitable for this type of quantitative analysis (Emlen 1971). Tables A8.5.1-2a through -2d summarized strip transect results and estimates of relative abundance and density for each transect.

8.5.2 Upland Gamebirds - Mourning Dove Relative Abundance

8.5.2.1 Scope and Rationale

Field observations during the baseline data accumulation program indicated that sage grouse and blue grouse populations are so sparse on and near the Tract that no reasonable monitoring program for them can be designed to determine changes over time; thus, a monitoring program for them is not warranted. The mourning dove is the only upland gamebird present in sufficient numbers to be monitored.

8.5.2.2 Objectives

The objective was to monitor the mourning dove populations to see if development of Tract C-b has affected their relative abundance.

8.5.2.3 Experimental Design

Methods used were identical to those used for songbirds. Throughout the year gamebirds observed were recorded on Wildlife Observation Reports.

8.5.2.4 Method of Analysis

The data were analyzed in the identical manner described for analyzing the relative abundance for the songbird-like population parameter.

8.5.2.5 Results and Conclusions

Table 8.5.2-1 shows mourning dove estimates on the four avifauna transects on Tract C-b. Mourning doves were not found on the developmental transects during the sampling periods. There are not enough data to make any conclusions at this time. However, the mourning dove transects will continue to be monitored closely next year to see if this was a one-year occurrence or if mourning doves have moved out of the developmental areas.

Table 8.5.2-1

Mourning Dove Estimates at Tract C-b for Spring Sample Period, 1978

Transect	Obs.	Coeff. Det.	Basal Adj.	Density /ha	% Relative Abundance
Chained Pinyon-Juniper (Control)	1	1.0	*	0.02	0.9
Pinyon-Juniper (Developmental)	0	-	-	-	-
Chained Pinyon-Juniper (Developmental)	0	-	-	-	-
Pinyon-Juniper (Control)	5	0.74	*	0.17	4.2

Other gamebirds seen on tract during 1978 included one sage grouse by the meteorological tower in October and one blue grouse in Sorghum Draw in December. Both birds were only observed one time. These birds were probably crossing Tract C-b to another location.

8.5.3 Raptor Activity

8.5.3.1 Scope and Rationale

Raptor activity was monitored on Tract C-b on a continuing basis because of the importance of raptors in the food chain, their apparent vulnerability to man's activities, their political value as threatened or endangered species, and their aesthetic appeal.

8.5.3.2 Objectives

The main objective was to detect changes in raptor utilization on or near Tract C-b.

8.5.3.3 Experimental Design

Trends in utilization of Tract C-b and immediately contiguous habitats by raptors were established for the breeding season by determining the percent of known nest sites which were occupied by nesting pairs and comparing this data with data obtained during the baseline period and following years. Nest occupancy checks were made annually during mid-March (great horned owls and ravens), late-April (red-tailed hawks, eagles), and early-June (accipiters, American kestrels, harriers). Throughout the year, any raptor sightings by the field biologists within the study boundary were recorded.

8.5.3.4 Methods of Analysis

Data analysis of nest occupancy was by professional judgment.

8.5.3.5 Results and Conclusions

Raptor nesting records for 1978 and the two previous years are listed in Table 8.5.3-1. Six active nests were located during the April sampling period, comprising of four red-tailed hawks and two great horned owl nests. Only three of the nests were active during the June census. All the nests contained young.

In addition to the nesting raptors, other raptors observed during 1978 on or near Tract C-b included: bald eagle, golden eagle, prairie falcon, Cooper's hawk, sharp shinned hawk, American kestrel, turkey vulture, common raven and marsh hawk. Most of these raptors were observed in only small numbers.

8.6 Aquatic Ecology

The variables of the aquatic program to be sampled through the environmental monitoring program are benthos, periphyton, and water quality. Because aquatic ecosystems could be secondarily affected by mining and development on tract, aquatic monitoring is essential. Benthos and periphyton are "indicators" of a significant change in stream characteristics downstream from oil shale development. The specific changes should be apparent in water quality parameters. In addition to the quarterly water analysis, daily water samples will be collected and stored for a month after periphyton are sampled and analyzed. If significant differences are noted in the primary indicators (periphyton and benthos) these daily samples can be analyzed to determine if changes in aquatic biota are due to a change in water quality. The daily water sampling will reflect rapid changes in water quality that may be short lived but still have an effect on the aquatic biota. Statistical comparisons to baseline data would show alterations of baseline conditions and indicate, through correlation coefficients, the severity of the impact so that timely corrections of detrimental conditions could be made.

8.6.1 Benthos

8.6.1.1 Scope and Rationale

The benthic species are important as lower-level consumers in the stream community as well as providing food for carnivorous species. They can be significant indicators of changes in the aquatic habitat. There are a number of organisms indicative of good or poor water quality conditions and qualitative data will give indication of changes in water quality.

8.6.1.2 Objectives

To infer water quality from invertebrate species present.

8.6.1.3 Experimental Design

The method used during the baseline and interim studies is continued during Development Monitoring. The surber sampler is used to make benthic collections at control and development stations on Piceance and Willow Creeks by the U.S.G.S. The following aquatic sampling stations established during the baseline period are used: WU07 (control) and WU61 and WU58

TABLE 8.5.3-1

RAPTOR NESTING RECORD

Nest No.	Species	Status 1976	Status 1977		Status 1978	
			April	June	April	June
1	Unknown	I	I	I	I	I
2	Unknown	I	I	I	I	I
3	Unknown	I	I	I	I	I
4	Red-tailed Hawk	E or Y	I	I	I	I
5	Unknown	I	I	I	I	I
5a	Common Raven	-	-	E or Y	I	I
6	Red-tailed Hawk	E	I	2Y	I	I
7	Red-tailed Hawk	I	I	-	E	I
8	Red-tailed Hawk	4Y	I	I	E	I
9	Common Raven	I	I	I	I	I
10	Red-tailed Hawk	I	I	I	I	I
11	Could not Locate					
12	Red-tailed Hawk	I	I	I	E	1Y
13	Red-tailed Hawk	I	I	I	I	I
14	Unknown	I	I	I	I	I
15	Unknown	I	I	I	I	I
16	Great Horned Owl	I	I	I	E	2Y
17	Great Horned Owl	I	I	I	I	I
18	Red-tailed Hawk	I	I	I	I	I
19	Great Horned Owl	1Y	I	I	I	I
20	Not on Map					
21	Not on Map					
22	Unknown	I	I	I	I	I
23	Not on Map					
24	Red-tailed Hawk	I	I	I	I	I
25	Great Horned Owl	I	I	I	I	I
26	Unknown	I	I	I	I	I
27	Unknown	I	I	I	I	I
28	Golden Eagle	1Y	I	I	I	I
29	Unknown	I	I	I	I	I
30	Red-tailed Hawk	2Y	I	I	I	I
31	Unknown	I	I	I	I	I
32	Great Horned Owl	2Y	2Y	-	I	I
33	Unknown	I	I	I	I	I
34	Unknown	I	I	I	I	I
35	Unknown	I	I	I	I	I
36	Red-tailed Hawk	2Y	I	I	I	I
37	Unknown	I	I	I	I	I
38	Unknown	I	I	I	I	I
39	Golden Eagle	1Y	I	I	I	I
40	Unknown	I	I	I	I	I
41	Unknown	I	I	I	I	I
42	Unknown	I	I	I	I	I
42a	Red-tailed Hawk	-	-	2Y	I	I
43	Great Horned Owl	2Y	I	I	E	2Y
44	Unknown	I	I	I	I	I
45	Red-tailed Hawk	2Y	I	I	I	I
46 (new)	Red-tailed Hawk				E	I

Code:

I = inactive nest
E = adult bird observed in an incubating posture; presumed to be incubating eggs
(2)Y = number of young observed in the nest
E or Y = adult bird observed in an incubating posture; due to time of year, assumed to be either incubating eggs or brooding very young chicks.

(development stations). (See jacket map for locations) Information from U.S.G.S. data will be used for correlations with data collected during environmental monitoring. Sampling occurs monthly and is coordinated with surface water sampling. During winter months benthos studies are discontinued due to inaccessibility dependent on weather conditions as determined by the U.S.G.S.

8.6.1.4 Method of Analysis

The following hypotheses will be tested in this analysis after sufficient data become available:

H_0: No significant change exists in Benthos communities over time.

H_0: No significant difference exists in Benthos communities at control stations vs. developmental stations from baseline data, recognizing the differences during baseline.

Hypotheses will be tested utilizing Shannon-Weiner diversity indices and T-test for proportions at $\alpha = 0.10$ level.

For each sampling period, the data will be summarized as follows: identify "ecologically important" taxa, determine percent relative abundance and diversity ($\bar{d}$) trends, compare these with previous sampling periods to ascertain seasonal trends, and compile a cumulative diversity ($\bar{d}$) table.

Each table will contain the following information:

1. Totals by order and/or family.
2. Totals by sample and station.
3. Percent relative abundance for (1) and (2).
4. Diversity ($\bar{d}$) for (1) and (2).
5. Maximum diversity ($\bar{d}$) for (1) and (2).
6. Equitability percent (e) for (1) and (2).
7. Number of taxa by sample, order, and/or family.

8.6.1.5 Results and Conclusions

C-b has not received benthic data from the Water Resources Division of U.S.G.S. for time period after May, 1978; therefore, limited results and conclusions are available at this time.

Table 8.6.1-1 summarizes the numbers of macroinvertebrates collected at six Piceance Creek stations during the two-year ecological baseline survey. (See Figure 8.6.1-1 for locations) The mean numbers of animals per square foot ranged from 25 at station PC-7 (Square-S Ranch site) to 79 at station PC-2 (just below Stewart Gulch site). Diptera, oligochaetes, and Ephemeroptera were, by far, the numerically dominant animals. Numerous studies of macroinvertebrates have shown that substratum and current velocity are important factors in determining the kinds and numbers present at particular sites.

The trend for numbers of kinds of invertebrates except aquatic worms to decrease at stations PC-6 (Hunter Gulch site) and PC-7 relative to upstream stations is probably more a reflection of increased amounts of silt and mud at these locations than to factors of temperature or water quality.

Table 8.6.1-1

Numbers of macroinvertebrates collected from Piceance Creek during 1974-1976

Taxon	P1	P2	P3	P5	P5a	P6	P7	Total
Ephemeroptera	319	240	402	303	190	116	36	1606
Odonata	0	0	0	0	0	0	4	4
Plecoptera	21	8	66	48	18	5	3	169
Trichoptera	12	5	12	23	2	1	0	55
Diptera	344	378	472	372	198	173	39	1976
Oligochaeta	240	515	118	114	209	275	245	1716
Other	68	42	68	63	28	17	2	288
Totals	1004	1188	1138	923	645	587	329	5814
Mean number/sample	67	79	76	62	54	42	25	

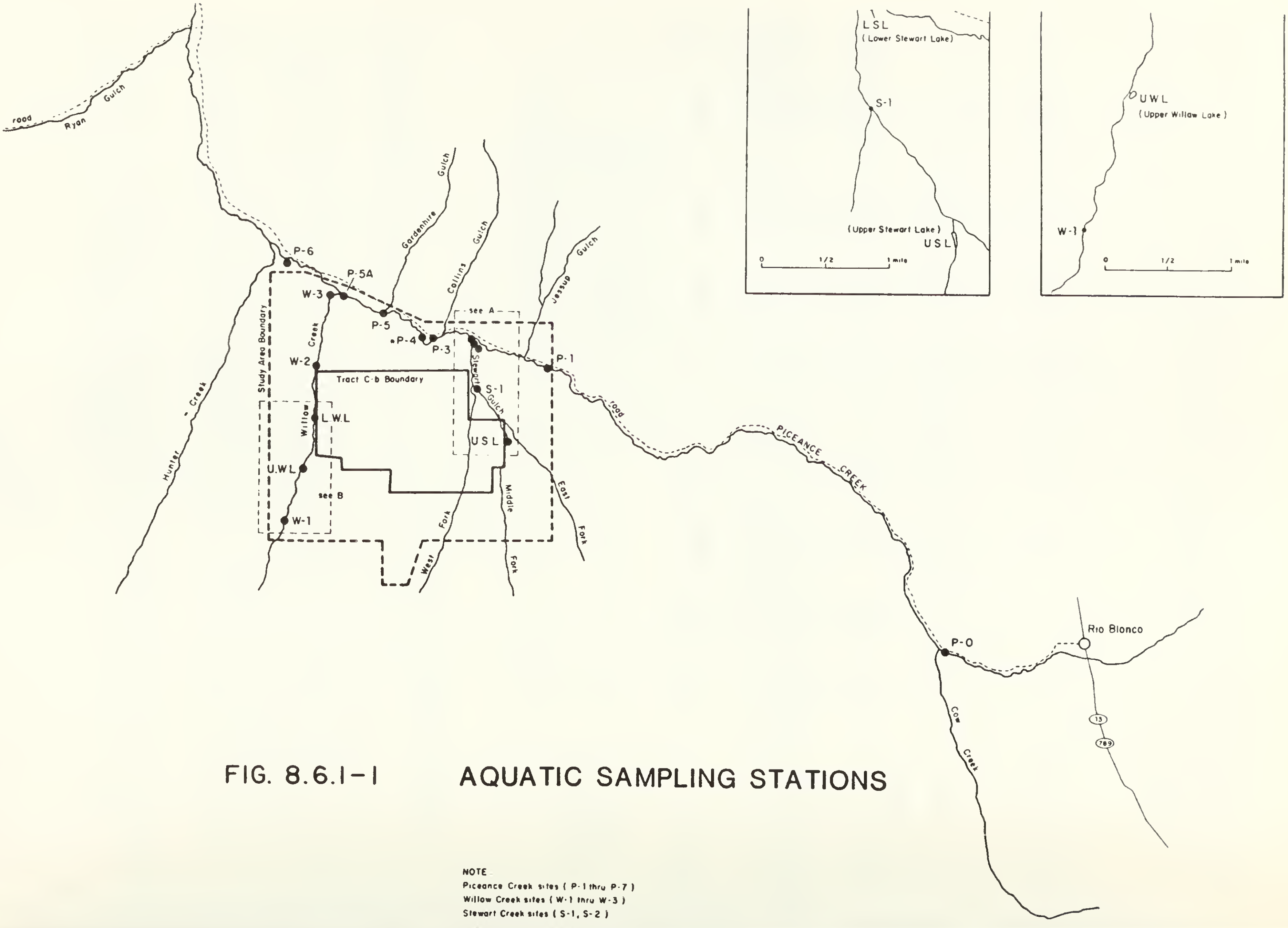


FIG. 8.6.1-1 AQUATIC SAMPLING STATIONS

NOTE
Piceance Creek sites (P-1 thru P-7)
Willow Creek sites (W-1 thru W-3)
Stewart Creek sites (S-1, S-2)
• P-4 has been relocated to P-5A

Everhart and May reported that the mean monthly numbers of benthic macroinvertebrates collected by them from four Piceance Creek stations in the period December 1968 through June 1969 was 144 individuals/ft^2 and from July through December 1969 it was 67/ft^2.

Numbers of macroinvertebrates in Piceance Creek samples were low; for example, eight samples from East Parachute Creek averaged 242 organisms/ft^2 and ten samples from West Parachute Creek averaged 474 individuals/ft^2 (Oil Shale Prototype Development Project, 1976). The same orders of insects that dominated Piceance Creek benthos were also dominant in Parachute Creek samples; however, oligochaetes were not an important part of the fauna there. Differences in type of substratum seem to be the chief casual factor in differences between Piceance Creek and Parachute Creek benthic faunas.

Not only were the numbers of macroinvertebrates in Piceance Creek small, but the individual organisms tend to be small. This is evident in the low fish food grade categories recorded during the two-year baseline survey. The volume of invertebrates (potential fish food) was usually in the poor grade (Lagler, 1956), i.e., less than 1 cc/ft^2. The average volume of macroinvertebrates reported by Everhart and May (1973) was less than 0.5 cc/ft^2.

Everhart and May's data are not strictly comparable to baseline because two of their invertebrate sampling stations were farther downstream than any of that program. However, their data are typical of results reported by other investigators, namely, a strong tendency for production of macroinvertebrates to be less downstream from Ryan Gulch than upstream from that point. The mean monthly biomass in Piceance Creek near its confluence with White River was from 1/12 to 1/40 that at their stations adjacent to Tract C-b.

8.6.2 Periphyton

8.6.2.1 Scope and Rationale

The periphyton communities are the major primary producers in the streams. They provide a major food source for benthic organisms and some fish species. They can respond very quickly to changes in water quality, and as such can be an important parameter for early detection of habitat degradation. Periphyton are stationary; therefore, they respond to changes in water quality at given locations. Locations are: Hunter Creek Gauging Station WU61, (PC-6 of Figure 8.6.1-1) and Stewart Gulch Gauging Station WU07 (PC-1).

8.6.2.2 Objective

The objective is to infer water quality and bioproductivity from species present.

8.6.2.3 Experimental Design

Collection of periphyton samples is accomplished monthly from two sites using artificial substrates (glass slides) which have been incubated in the water for at least 21 days. Sampling ran from May 1, 1978 to November 1, 1978, resulting in six collections. Six glass slides were incubated at each of the two locations. At the time of collection, three slides are collected at each location and placed in individual plastic containers for biomass analysis (total of 6 slides). Also, three additional slides are collected in individual plastic containers and preserved with "M-3" preservative, a modified Lugol's solution, for taxonomic identification and enumeration (total of 6 slides).

The slides collected for biomass are oven dried at 105°C to constant weight. They are then weighed to the nearest milligram, ashed at 500°C, rewetted with distilled water to replace the water of hydration, oven dried, and weighed again. Biomass is reported as mg ash-free dry weight per cm^2.

Slides collected for taxonomic identification and enumeration are scraped into an appropriate volume of water along with a sufficient amount of preservative to limit microbial growth and/or algal decomposition. The resulting solution is mixed thoroughly, and an aliquot withdrawn for quantitative analysis using aninverted microscope at a magnification of 560X.

8.6.2.4 Methods of Analysis

The following data are tabulated:

1. Species identification.
2. Total taxa by sample and station.
3. Density (units/cm^2).
4. Percent relative abundance.
5. Biomass (mg/cm^2) per sample.
6. Diversity (d).
7. Maximum diversity ($\log_2$ number of species).
8. Equitability percent.

Diversity measurements will indicate, by the relative abundance of certain indicator species, the relative impact of oil shale development on the periphyton communities.

The following hypotheses will be tested in this analysis:

H_0: No significant change exists in periphyton communities over time.

H_0: No significant difference exists in periphyton communities at control stations vs. development stations from baseline data, recognizing the differences during baseline.

Statistical analyses will be a comparison of productivity (biomass) and species diversity during monitoring versus baseline conditions, and include analysis of variance, correlation analysis, as well as non-parametric tests. A significant difference is based on statistical analysis and professional judgment. If the null hypotheses are rejected at α =0.10 level, daily water samples will be analyzed, periphyton sampling may be intensified in an effort to pinpoint the degradation, and as previously noted a systems dependent (fish shocking) study may be initiated.

8.6.2.5 Results and Conclusions

A total of 106 taxa were identified from Hunter and

Stewart Stations in Piceance Creek, Colorado from the monthly samples taken between May and October 1978 (Tables A8.6.2-1 through A8.6.2-6. These taxa were comprised of 84 diatom taxa (Bacillariophyta), 12 green algae taxa (Chlorophyta), six blue-green algae taxa (Cyanophyta), one cryptomonad taxon (Cryptophyta), and three yellow-brown algae taxa (Chrysophyta). Table A8.6.2-7 lists the taxa observed and their months and locations of occurrence and dominance during the study. Species diversity and biomass data for the six month study are summarized in Tables A8.6.2-8 and A8.2.6-9.

Variations in periphyton density occurred during the study period with minima recorded in May and maxima recorded the following month, June. Extreme station density differences occurred in August when the total density at Stewart Station was nearly five times less than at Hunter Station and in October when the total density at Hunter Station was over five times less than at Stewart Station.

In comparing the periphyton communities observed throughout the six month study period, a seasonal variation is apparent. In May and June the periphyton of both stations was predominately Navicula and Nitzschia species. In July, August, and September, both stations were predominated by Achnanthes species with Cocconeis species becoming codominant in August and September. October was the only month where significant differences were observed in the periphyton constituents of the two stations. Stewart Station continued to be dominated by Achnanthes and Cocconeis species while at Hunter Station the importance of Achnanthes species was diminished and Navicula and Cocconeis species occurred as dominants in the periphyton.

Annual variations also seem to be occurring in Piceance Creek based on comparisons of 1978 sampling to spring and fall periphyton analyses in 1977. In May 1977 Navicula viridula var. avenacea dominated while in 1978 other Navicula species and Nitzschia species dominated along with Cocconeis placentula at Hunter Station. The October 1978 samples at Hunter Station were similar to those observed in 1977. Stewart Station, however, was quite dissimilar with Achnanthes and Cocconeis species dominating.

The known ecological requirements and tolerances were similar for the diatom species found to dominate at some time in the study. They attain best development in alkaline waters and are common in oligotrophic and mesothropic rivers of this region (Lowe 1974 and Patrick and Reimer 1966). The Nitzschia species that dominated in spring and summer, however, are generally more common in standing waters.

Species diversity values for the study are summarized in Table A8.6.2-8. Diversity values decreased steadily at both stations between May and July then increased again in August. In September and October at Stewart Station the diversity was extremely low. In October the differences between stations apparent from the dominant taxa was also visible when comparing diversity values with Hunter Station diversity being considerably higher.

Biomass data are summarized for the study in Table A8.6.2-9. At Stewart Station mean biomass steadily decreased from 0.52 mg/cm^2 in May to 0.05 mg/cm^2 in August, increased to 0.35 mg/cm^2 in September, then decreased again to 0.13 mg/cm^2 in October. At Hunter Station, biomass increased to a maximum in June (1.66 mg/cm^2) and steadily decreased to the minimum recorded in October (0.22 mg/cm^2). During the six month study, productivity as determined by the biomass was highest at Hunter Station.

In addition to the 1977 and 1978 periphyton data discussed in previous pages periphyton data were collected in 1974, 1975, and 1976 from Piceance Creek, Colorado (C-b Shale Oil Venture et. al 1977).

In comparing the 1974-1976 periphyton data to the 1977-1978 data, difficulties arise because sampling sites for the two studies were changed and in 1974-1976 there were gaps in the data collected due to destroyed samplers. For these reasons, meaningful comparisons can only be made between data collected from Stewart and Hunter Stations for 1977-1978 and data collected from similar sites at Stewart and Hunter Stations for 1974-1976.

Station PC-3 with periphyton community analysis data for 1974, 1975, and 1976 (Table A8.6.2-10) and biomass productivity data for 1975 and 1976 (Table A8.6.2-12) is downstream from and has been compared to Stewart Station. Station PC-6 with periphyton community analysis data for 1974, 1975, and 1976 (Table A8.6.2-11) and biomass productivity data for 1975 and 1976 (Table A8.6.2-12) is downstream from and has been compared to Hunter Station.

The periphyton community analysis data for 1974-1976 is qualitative only. No information is available for comparison on periphyton abundance and dominance.

Since the occurrence of a taxa in a sample could indicate the chance presence of a single individual unsuited to the present environmental conditions rather than a growth response of an organism to favorable conditions, dominant taxa (present at abundances greater than 5% of the total abundance) are often used to describe an algal community. In the case of the 1974-1976 data where dominance was not indicated, taxa dominating in 1977 and 1978 have been compared to those occurring in 1974-1976.

In the vicinity of Stewart Station there appears to be considerable annual variation in the periphyton community.

In spring 1978, *Navicula tripunctata* var. *schizonenoides*, *Navicula secreta* var. *apiculata*, *Nitzschia palea*, *Nitzschia* spp., and other pennate diatoms were the dominant taxa while in 1977 *Navicula viridula* var. *avenacea* was the only taxa present as a dominant. In 1976, when spring collection data is available, *Navicula viridula* and *Nitzschia palea* were the only taxa recorded that corresponded to the 1977 and 1978 dominants.

In summer 1978, three *Achnanthes* species, two *Cocconeis* species and *Navicula secreta* var. *apiculata* were the dominant taxa. Two of these six taxa were recorded as having occurred in 1976, *Achnanthes* sp. and *Cocconeis placentula*, while in 1975 *Cocconeis placentula* was the only taxa of the 1978 dominants recorded as present.

In fall, major annual differences were apparent in the vicinity of Stewart Station. In 1978 *Achnanthes minutissima* and *Cocconeis pediculus* dominated the periphyton. *Navicula secreta* var. *apiculata* and *Navicula viridula* var. *avenacea* were the dominant taxa, in 1977. Of the taxa found in abundance in 1977 and 1978, *Navicula viridula* occurred in the fall periphyton collection in 1975 and *Cocconeis* sp. and *Navicula* sp. occurred in 1974.

In the vicinity of Hunter Station some annual variation was apparent. In spring 1977, *Navicula viridula* var. *avenacea* dominated the periphyton community. In addition to this taxa, in 1978 *Achnanthes minutissima*, *Navicula cryptocephala*, *N. secreta* var. *apiculata*, *N. viridula* var. *avenacea*, *N. tripunctata* var. *schizonemoides*, *Nitzschia palea*, *Nitzschia* spp., and other pennate diatoms occurred as dominants. Of these 1977 and 1978 dominant taxa, *Navicula cryptocephala* and *N. viridula* were recorded from the periphyton in the spring of 1975 and 1976.

In summer during 1978, three *Achnanthes* species and two *Cocconeis* species dominated the periphyton collection. Of these taxa *Cocconeis placentula* was recorded occurring in 1975 and 1976. In addition, *Achnanthes lanceolata* occurred in 1976.

In fall 1977 *Navicula viridula* var. *avenacea* and *N. secreta* var. *apiculata* were the dominant taxa. In 1978 the dominant taxa were these same two *Navicula* taxa, *Achnanthes lanceolata* var. *dubia*, and two *Cocconeis* species. Of these dominant taxa of 1977 and 1978, two occurred in the fall samples of 1975, *Navicula viridula* and *Cocconeis placentula*. In 1974 *Achnanthes* sp., *Cocconeis placentula*, and *Navicula* sp. were the taxa occurring in common with the 1977 and 1978 dominants.

Differences in sampling techniques and levels of taxonomic expertise may be responsible for some of the variation observed between the periphyton communities of 1974-1976 and 1977-1978. Although annual differences have apparently occurred, the reasons for these differences are not immediately apparent. Combinations of a number of environmental factors such as light (turbidity), temperature, flow rate, nutrients, and pH all effect the periphyton community. Any or all of these factors may vary on an annual basis irrespective of any man-made perturbations.

Although variability in the periphyton communities is apparent annually, seasonally, and between stations, most of the taxa observed over the five year study in the vicinity of Stewart and Hunter Stations were diatoms with similar environmental requirements. According to Lowe (1974) most of the diatom taxa observed attain best development in alkaline waters (pH> 7) of relatively high inorganic nutrient concentrations. They are common in small or large streams of ponds. Most of the taxa recorded as abundant are considered to be cold water forms.

The seasonal fluctuation apparent in ash-free dry weight biomass productivity was highest in summer and fall when light and temperature were optimum for growth. Spate and drought occurrences are probably the most important factors governing the time and degree of high productivity in the summer and fall. In 1975 productivity was high in late summer and fall while in 1976 the high values occurred in spring and early summer with a low value in mid-summer (July). A July 1976 high flow rate of approximately 40 cfs could have scoured the periphytic algae from the glass slides and reduced the recordable biomass productivity. Simarily in August 1978 productivity was low. Increased flow rate was probably the reason for this also. On an annual basis the range of productivity values recorded were generally comparable over the five year study.

Productivity at the different stations was also variable. In 1975, 1976, and 1977 biomass productivity tended to be higher at Stewart Station than at Hunter Station while in 1978 the reverse was true. Continued study will be required to determine if this trend will continue. Figure 8.6.2-1 graphically presents the productivity results for 1975-1978.

8.6.3 Water Quality

Surface water quality is now consolidated in Section 5.2

8.7 Terrestrial Studies

The terrestrial studies portion of the Environmental Baseline Program was designed to describe the predevelopment, biological environment within the study area (the dotted lines of the jacket map) and to provide baseline data to be used in monitoring changes in the biota as a result of oil shale development. Baseline parameters were selected for their usefulness in describing the existing environment on Tract C-b. Development monitoring parameters were judged to be useful because of their measurability or observability or relative low natural variability, and/or sensitivity to expected environmental perturbations. Sample locations during Development Monitoring are shown on the jacket map.

8.7.1 Vegetation Community Structure and Composition

8.7.1.1 Scope and Rationale

The vegetation community structure and composition studies are conducted to evaluate major changes in the makeup of the major plant communities on the Tract. Other vegetation monitoring programs provide a better means for statistically evaluating changes. The structure and composition studies are better used for evaluating general vegetational trends. These studies are centered on the six intensive study sites which are sampled on a three year rotational basis. Chained pinyon-juniper rangeland Plots were sampled in 1978, pinyon-juniper woodland Plots will be sampled in 1979 and sagebrush Plots will be sampled in 1980.

8.7.1.2 Objectives

The objective of the community structure and composition studies is to obtain long-term data from permanently located sampling quadrats so as to evaluate differences in numerous species. The productivity studies, discussed later, focus on monitoring a process; the structure and composition studies focus on the performance of species within the major vegetation types.

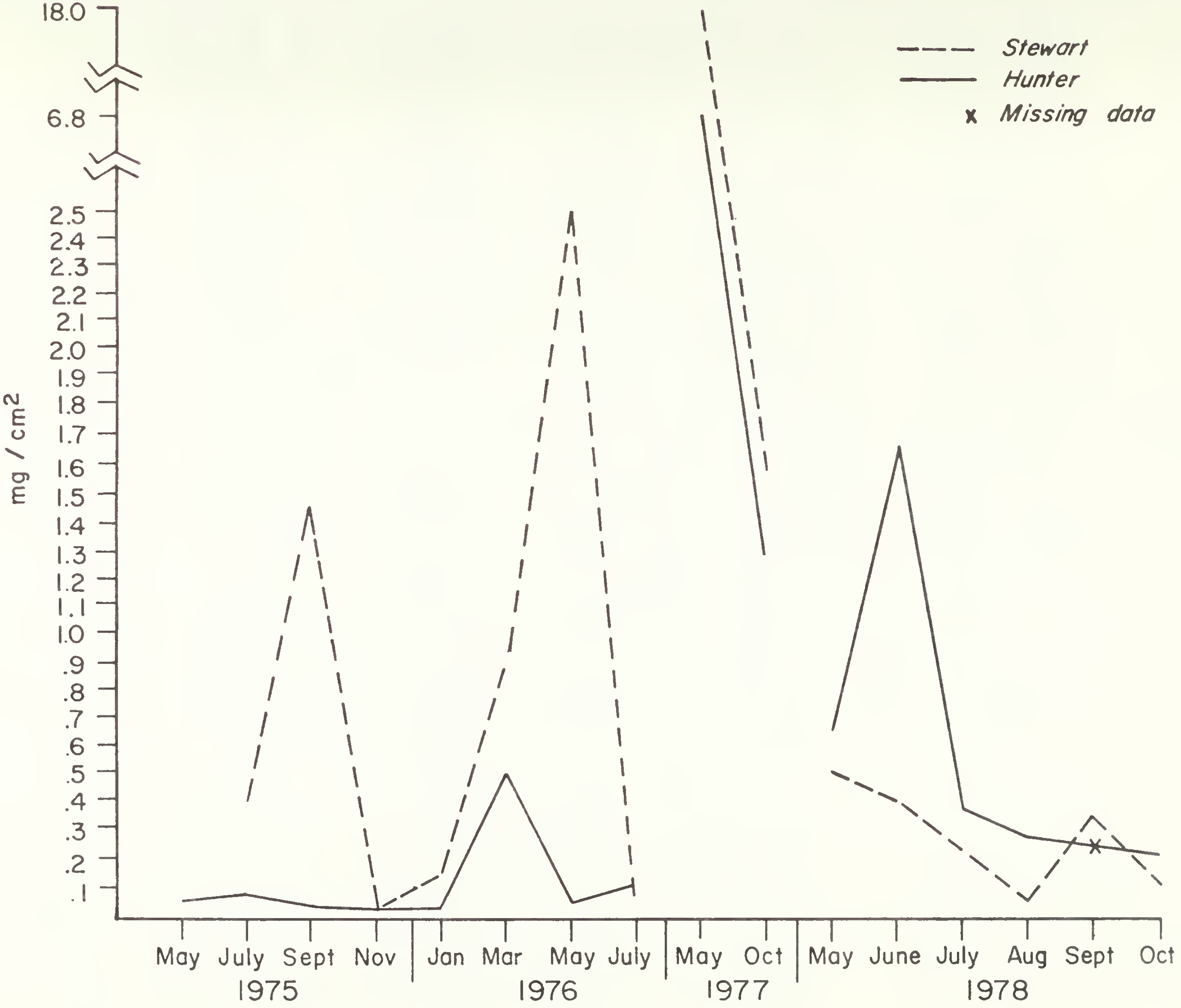


FIGURE 8.6.2-1 PERIPHYTON ASH-FREE DRY WEIGHT PRODUCTIVITY (mg/cm^2) FROM PICEANCE CREEK, COLORADO IN THE VICINITY OF STEWART AND HUNTER STATIONS, 1975-1978

8.7.1.3 Experimental Design

The community structure and composition studies are conducted at the six intensive study plots. Two are located in the pinyon-juniper woodland type, two in the chained rangeland type and one each in the bottomland sagebrush and upland sagebrush types. At each location a grid of 25 1.0m^2 quadrats has been established in a permanently fenced and an adjoining open area (a grid in each for a total of 50 quadrats for each site). Observations on herb layer species are made in the 1.0 m^2 quadrats.

Shrubs are sampled along line-strip transects. The center posts marking the herb quadrats serve as end points of the transects, thus producing a total of 20 line-strips per grid. The herb quadrats are established on 10 meter centers. The line-strips are 10 meters long and 4 meters wide. In the woodland plots, trees are surveyed within the 10m x 4m transects. The following parameters are being monitored: cover and frequency for herbs; cover, frequency, and density for shrubs; and diameter and canopy cover for trees.

8.7.1.4 Method of Analysis

Data from the community structure and composition studies have been evaluated mostly through the use of trend analysis. Total vegetation cover in the herb layer will be evaluated in a future report using a one-way analysis of variance test to examine yearly differences in total cover.

8.7.1.5 Results and Conclusions

Herb quadrat summaries for Plot 1-0 and Plot 1-F are presented in Tables A8.7.1-1 and A8.7.1-2. In order to provide more information about the vegetation at these sites, individual estimates of species cover were made during 1978. These data were not recorded during the baseline period.

Species composition at both Plots 1-0 and 1-F is essentially the same as it was during the baseline period. Annual species continue to be somewhat variable, and frequency values for these species tend to be more subject to changes than for perennial species. There was no significant difference in total cover between 1978 and 1975 and 1976 at either Plot 1-0 or Plot 1-F.

Herb quadrat summaries for Plot 2-0 and Plot 2-F are presented in Tables A8.7.1-3 and A8.7.1-4. No major differences were noted in species composition in either plot. At Plot 2-0, the differences in total cover observed in 1978 were not significant compared with the values obtained during the baseline years. At Plot 2-F, however, the differences between 1975 and 1978 and between 1976 and 1978 were significant with 1978 having less cover than in either of the other years.

Shrub species frequency, mean cover and relative cover have not changed substantially over the last 4 years at Plots 1-0, 1-F, 2-0, and 2-F (Tables A8.7.1-5 to -8). Values were not tested statistically; however, the 1978 values appear to be comparable to those obtained during the baseline period.

During 1978, Juniperus scopulorum was not separated from Juniperus osteosperma. The fact that J. scopolorum did not appear in the data was a result of misidentification. Density values for shrubs were also comparable to those obtained during the baseline period (Table A8.7.1-9). The variability in the data is somewhat higher, mainly because density is a more difficult parameter to measure than cover or presence. One general trend which can be seen is an increase in the number of sagebrush plants.

8.7.1.6 Conclusions

The monitoring data suggest that over the past four years there have been no major changes in species composition or community structure in the chained rangelands. The general trend has been for a slight increase in total cover and also for an increase in the density of big sagebrush. These changes are closely related to the successional characteristic of the chained rangelands. The trend for increasing shrub cover and density is likely to continue until the tree saplings mature into tree-size individuals.

8.7.2 Herbaceous Productivity and Utilization

8.7.2.1 Scope and Rationale

Productivity of vegetation is intrinsically important in the operation of ecosystems on Tract C-b. The amount of production and availability of food are both of consequence for animal species within the system. Any significant interruption in production may well be manifested in changes throughout the system. In terms of monitoring, herbaceous production is a more convenient parameter to measure and is a reflection of the total production in any of the communities on the Tract. By monitoring the herbaceous production it is possible to evaluate yearly and site-to-site differences in productivity.

The scope of the herbaceous productivity and utilization studies includes sampling on Tract-wide basis, sampling at the intensive study sites established during the baseline studies period, sampling control and treatment sites north of Piceance Creek in an area which may possibly be impacted by industrial development, and also sampling in native communities fertilized in order to increase production.

8.7.2.2 Objectives

The objectives of the productivity and utilization studies are to provide a means for measuring trends of herbaceous production and utilization, to provide a way of evaluating changes in production related to development activities, and to evaluate any changes in utilization by grazing.

8.7.2.3 Experimental Design

Herbaceous production and utilization are being studied on a Tract-wide basis through the use of randomly located exclosures. These exclosures (range cages) are small in size and prevent grazing by large herbivores on more than one square meter of ground. Ten exclosures are placed throughout the Tract in each of the four major plant communities (pinyon-juniper woodlands, chained pinyon-juniper rangelands, upland sagebrush shrublands, and bottomland sagebrush shrublands). The range cages are clipped in late July and all of the current years growth is fractionated on the basis of species for western wheatgrass (Agropyron smithii), cheatgrass (Bromus tectorum), and Indian ricegrass (Oryzopsis hymenoides); and on the basis of life form for other perennial grasses, other annual grasses, perennial forbs, annual forbs, and half-shrubs. At the same time the cages are clipped, a randomly located quadrat of the same size is clipped in an area close to the range cage in order to obtain the necessary data for evaluating utilization. The clipped samples are returned to the lab, oven dried to a constant weight, and then weighed to the nearest milligram.

Production studies at the intensive study sites are being conducted using a double sampling approach. Fifty one-square meter quadrats are randomly located in seasonally fenced plots at the intensive study sites. (Fences are put up at the beginning of the growing season and removed after the studies have been completed at the end of the season). The weight in grams for each of the current years growth fractions is estimated in each of the fifty quadrats. Ten of the quadrats are clipped in addition to being estimated. Once the samples have been dried and weighed, regression equations are developed for each of the species or species groups. All of the fresh estimates are then corrected to an oven dry weight on the basis of the derived equations. Total production estimates are derived from an equation rather than by summing individual fractions for each quadrat. Data from these studies are compared with information derived during baseline periods and are also used to compare vegetation types and study sites within any given year.

The areas north of Piceance Creek have been identified as possible sulfur dioxide accumulation areas. In order to evaluate potential air pollution effects, herbaceous production estimates are to be obtained in the affected area as well as in a comparable control area. In 1978 both the affected and control sites were sampled using ten randomly located range cages in each area. Open areas near each of the cages were also clipped in order to evaluate utilization at each site. Samples were obtained and handled in the same manner as that used for other range cage studies. These data will serve as the baseline for evaluating changes in the affected area.

The effects of fertilization in native vegetation types are also being monitored. Two different fertilizer treatments (ammonium nitrate and ammonium nitrate plus phosphorus) are being employed at two sites in the chained rangeland community type. One range cage is randomly located within each treatment at each site.

Control data are obtained from sites adjacent to the fertilizer application areas. Open areas near the range cages are clipped in order to evaluate utilization in the fertilizer areas. The data are collected and handled in the same manner as in other range cage studies.

8.7.2.4 Methods of Analyses

Analysis of the herbaceous production data is focused on four areas of comparison. These include the evaluation of:

1. Differences among vegetation types during a given growing season.
2. Differences between study sites of the same vegetation type during a given growing season.
3. Differences between years within a given vegetation type.
4. Differences between fenced and open areas within a vegetation type during a given growing season.

Total production is used as the parameter for comparison. Evaluation of differences is accomplished using a one-way analysis of variance (F-test) to test whether or not the means in question are the same.

8.7.2.5 Results and Discussion

Tract-wide Range Cage Studies. The Tract-wide range cage studies were used to obtain a more broadly based estimate of production than that derived from the intensive study plots. Each of the four major vegetation types is discussed separately.

Data from each of range cages sampled in the pinyon-juniper woodland type are presented in Table A8.7.2-1. Total production in the pinyon-juniper woodlands averaged 21.4 g/m^2 (191 lbs/ac) and only 9.8 g/m^2 (87 lbs/ac) in open areas near the cages (Table A8.7.2-2). In both cases most of the production was attributable to perennial grasses. Annual forbs and half-shrubs occurred only sporadically.

Oven dry weight data from the chained rangeland range cages and open areas are presented in Table A8.7.2-3. Total production averaged 63.5 g/m^2 (566 lbs/ac) for the range cages and 53.2 g/m^2 (474 lbs/ac) for the open areas. The greatest percentage of the production was attributable to Indian ricegrass, western wheatgrass and the other perennial grasses (Table A8.7.2-4)

Oven dry weight data for range cages and open areas in the upland sagebrush shrubland type are presented in Table A8.7.2-5 . Total production averaged 68.0 g/m^2 (606 lbs/ac) in the range cages and 47.2 g/m^2 (420 lbs/ac) in the open areas. Major producing species included western wheatgrass and other perennial grasses (Table A8.7.2-6). Forbs accounted for less than 10 percent of the total production. Half-shrubs were encountered occasionally; however when they occurred in the sample, they contributed substantially to the total production.

Data from the range cages and open areas in the bottomland sagebrush shrubland type are presented in Table A8.7.2-7. Total production averaged 32.9 g/m^2 (293 lbs/ac) in the range cages and 16.6 g/m^2 (148 lbs/ac) in the open areas. The dominant species was cheatgrass which accounted for 45 percent of the production in the range cages and 34 percent of the production in the open areas (Table A8.7.2-8).

Intensive Study Plots - 1977. Field data and oven dry weights from May, June and July, 1977 for the six intensive study plots were presented in the 1977 Tract C-b interim monitoring data report. The results presented in this section are summaries based on regression equations derived from the May, June and July data (Tables A8.7.2-9 to -11).

1977 was a very dry year on the Tract, and total production estimates were substantially lower than those reported for previous years. Not only were the production estimates lower, but the pattern of seasonal development was also different from previous years. In some cases the maximum standing crop was attained in May, whereas in more normal precipitation years maximum standing crop was not reached until July.

Production data for chained rangeland Plots 1-0 and 1-F for May, June and July are presented in Tables A8.7.2-12 to -14. Maximum standing crop in the fenced plot was 11.1 g/m^2 (99 lbs/ac) and was measured in July. In the open plot maximum standing crop was 8.8 g/m^2 (78 lbs/ac) and was also measured in July. Most of the production in both the open and fenced plots was attributable to perennial grasses. In chained rangeland Plots 2-0 and 2-F (Tables A8.7-2-15 to -17) the maximum standing crop was 12.5 g/m^2 (111 lbs/ac) in May for the fenced plot and 9.5 g/m^2 (85 lbs/ac) in May for the open plot.

Maximum standing crop in the upland sagebrush shrubland type (Plots 3-0 and 3-F) was reached in May (Tables A8.7.2-18 to -20). In Plot 3-F the maximum standing crop was 18.2 g/m^2 (162 lbs/ac) and in Plot 3-0 was 12.2 g/m^2 (109 lbs/ac). Most of the standing crop was attributable to western wheatgrass and other perennial grasses.

Production data for the bottomland sagebrush Plots 4-0 and 4-F (May, June and July) are presented in Tables A8.7.2-21 to -23. Maximum standing crop for both the open and fenced plots was measured in July. In the fenced plot total production was only 4.5 g/m^2 (40 lbs/ac) and in the open plot was only 4.6 g/m^2 (41 lbs/ac). Cheatgrass, which had been encountered as a major species in previous years, was nearly absent from the sample. Cheatgrass is an annual species and under the very dry conditions of the 1977 growing season, grew hardly at all.

Production data for pinyon-juniper woodland Plots 5-0 and 5-F are presented in Tables A8.7.2-24 to -26. Maximum standing crop in Plot 5-F averaged 6.2 g/m^2 (55 lbs/ac) and occurred in May. In Plot 5-0 the maximum standing crop was only 5.1 g/m^2 (45 lbs/ac) also recorded in May. Most of the production was provided by perennial grasses. Production at the other pinyon-juniper study site (Plots 6-0 and 6-F) was somewhat higher than at Plot 5 (Tables A8.7.2-27 to -29). Maximum standing crop averaged 6.4 g/m^2 (57 lbs/ac) in Plot 6-F in July and 9.9 g/m2 (88 lbs/ac) in Plot 6-0 in May. As in Plot 5, most of production was provided by perennial grass species.

Intensive Study Plots - 1978. During 1978, clipping studies were conducted only in Plots 1-F, 2-F, 5-F and 6-F, and sites were clipped only once during the growing season (late July). At this date all of the material produced during the growing season was clipped. Fresh weight estimates for each of the plots are presented in Tables A8.7.2-30 to 33, and the oven dry weights for each of the clipped quadrats are presented in Tables A8.7.2-34 and 35. The dry weight estimates and corresponding oven dry weights were used to develop the regression equations in Table A8.7.2-36.

Based on data derived from the regression equations the production at Plot 1-F averaged 29.5 g/m^2 (263 lbs/ac) (Table A8.7.2-37). The major species were Indian ricegrass and other perennial grasses. At Plot 2-F herb production averaged 24.4 g/m^2 (217 lbs/ac) (Table A8.7.2-37). Major species at this site included western wheatgrass, Indian ricegrass and other perennial grasses. Cheatgrass was also quite abundant and averaged 4.0 g/m2 (36 lbs/ac).

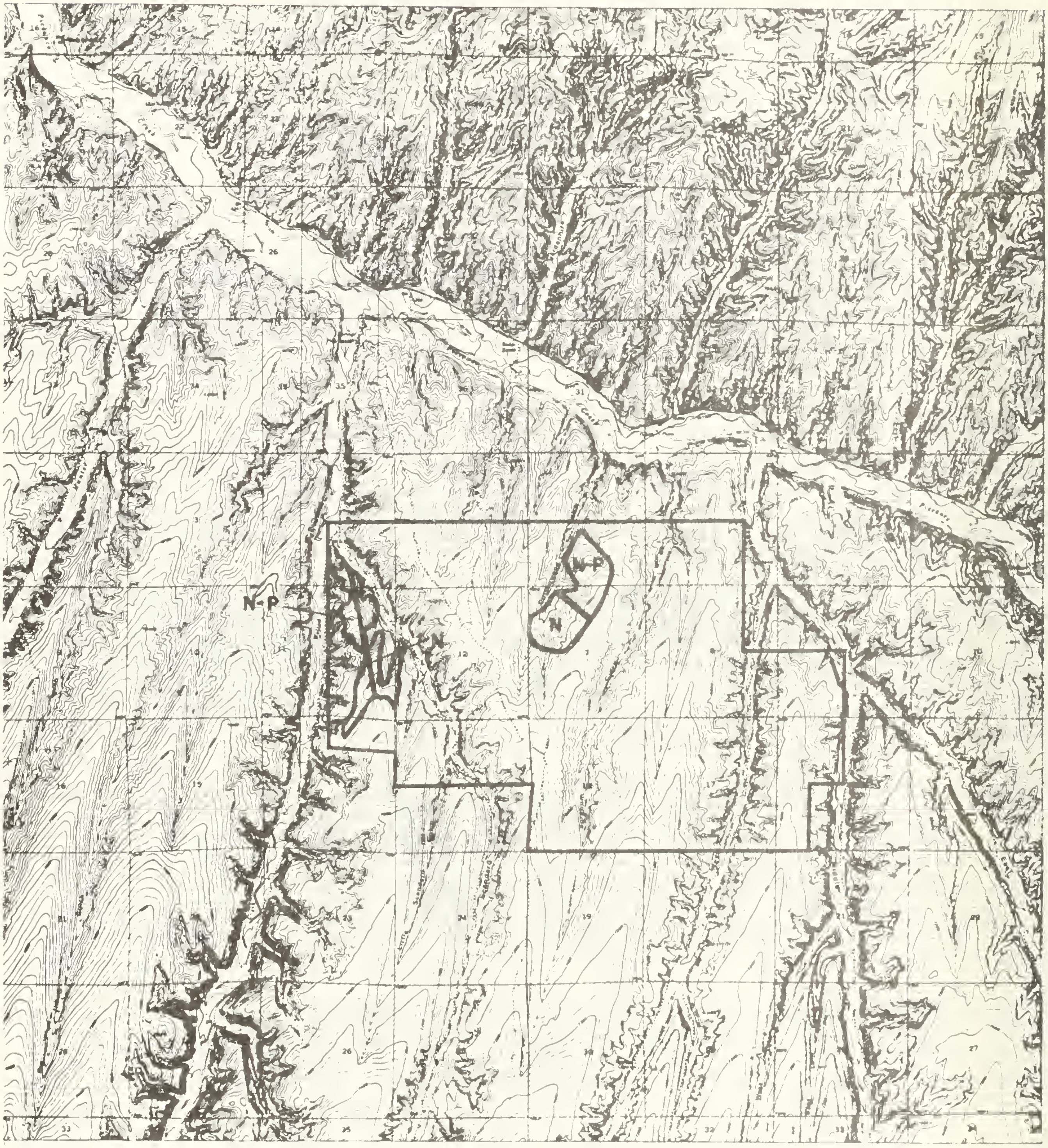
Production at pinyon-juniper woodland Plot 5-F was lower than that for the chained rangeland sites and averaged only 19.2 g/m^2 (171 lbs/ac) (Table A8.7.2-38). Major species included Indian ricegrass and other perennial grasses. Plot 6-F was more than twice as productive and averaged 50.3 g/m^2 (448 lbs/ac) (Table A8.7.2-38). This same relationship between plots 5-F and 6-F was observed during the baseline period and to a lesser extent during the suspension monitoring period.

Studies Conducted North of Piceance Creek. Oven dry weight data for range cages and open areas in the anticipated affected area and control area are presented in Tables A8.7.2-39 and 40, respectively. On the affected area site, production averaged 19.7 g/m^2 (175 lbs/ac) in the range cages and 9.8 g/m^2 (87 lbs/ac) in the open areas. In both instances most of the production was attributable to Indian ricegrass and other perennial grasses (Table A8.7.2-41).

In the control area, production averaged 17.8 g/m^2 (150 lbs/ac) in the range cages and 6.6 g/m^2 (59 lbs/ac) in the open areas (Table A8.7.2-42). Indian ricegrass and other perennial grasses were the most productive species. The pinyon-juniper woodlands on these sites north of Piceance Creek occur on dry, south-facing slopes. In terms of slope and aspect, they are quite similar to intensive study Plot 5 on the Tract. It is interesting to note that the production on the control and affected area sites was comparable to that measured at Plot 5-F.

Fertilization Studies. Fertilized areas are shown on Figure 8.7.2-1. Oven dry weights from range cages and open areas in the different fertilizer treatment locations are presented in Table 8.7.2-1. These data were grouped in various ways in order to evaluate the effects of fertilization, location effects, and grazing effects in the fertilizer plots.

N-P AMMONIUM NITRATE & PHOSPHOROUS FERTILIZER APPLICATION
N AMMONIUM NITRATE



FERTILIZATION MAP

FIGURE 8.7.2-1

Table 8.7.2-1 . Production values (oven dry weights in grams/m^2) from range cages and open plots for fertilized and non-fertilized areas on the Ridge above Cottonwood Gulch and Scandard Ridge. 1978.

	Ridge Above Cottonwood Gulch		Scandard Ridge	
	Fenced Plot	Open Plot	Fenced Plot	Open Plot
Fertilized with Ammonium Nitrate and Phosphorus				
Agropyron smithii	18.076	15.575		
Bromus tectorum			45.251	46.747
Oryzopsis hymenoides	28.119	30.727	9.189	33.980
Other perennial grasses	26.872	6.874	0.206	1.179
Perennial forbs	8.092	5.039	0.005	4.639
Annual forbs			0.157	0.088
Total biomass	81.159	58.215	54.808	86.633
Fertilized with Ammonium Nitrate				
Agropyron smithii	10.152	15.163	0.205	
Bromus tectorum		6.055		
Oryzopsis hymenoides		0.923	0.236	
Other perennial grasses	73.040		25.243	27.770
Perennial forbs			0.801	1.480
Annual forbs		6.691		0.675
Total biomass	83.192	28.832	26.485	29.925
Not Fertilized				
Agropyron smithii	11.314	5.466	7.854	
Bromus tectorum	0.158	0.670	0.092	0.707
Oryzopsis hymenoides				
Other perennial grasses	51.343	0.840	17.839	28.442
Perennial forbs	6.284	5.299	4.028	
Annual forbs	0.129	0.154		0.256
Half shrubs		0.128		
Total biomass	69.228	12.557	29.813	29.405

There was no significant difference between the production in the fertilized and non-fertilized areas (tested with an F-test at $\alpha = 0.10$). The mean production on the fertilized area was greater (56.2 g/m^2) compared with non-fertilized (35.2 g/m^2), however the difference was not significant. Also, the differences in the type of fertilizer used were not significant (42.1 g/m^2 with ammonium nitrate alone and 70.2 g/m^2 with ammonium nitrate plus phosphorus). There was no significant difference between the plots on Scandard Ridge and those on the ridge above Cottonwood Gulch. Considering all the range cages used in the fertilization study there were no significant differences between the range cage and the open quadrats, suggesting limited utilization of the two sites as whole. However, the difference between the open quadrats and range cages on the ridge above Cottonwood Gulch was significant.

At this time the results from the fertilization studies are inconclusive. Apparently the fertilization is causing an increase in production, but because of the variability of the data and the limited sample sizes these differences are statistically not significant.

Evaluation of Production Differences.

Differences Among Vegetation Types. Because of the increased sample size associated with the change in methods used for estimated production, it has been possible to more clearly evaluate differences among the four major types (Table 8.7.2-2). In 1977 the chained rangelands were significantly more productive than both the pinyon-juniper woodlands and bottomland sagebrush shrublands. The upland sagebrush shrublands were significantly more productive than any of the other vegetation types. The pinyon-juniper woodlands were significantly more productive than the bottomland sagebrush shrublands. In 1978 the chained rangelands and upland sagebrush shrublands were significantly more productive than the pinyon-juniper woodlands and bottomland sagebrush shrublands. The differences between the pinyon-juniper woodlands and bottomland sagebrush shrublands, and between the chained rangelands and upland sagebrush shrublands were not significant in 1978. The pattern of differences observed in both 1977 and 1978 is consistent with the data obtained during the baseline period. In terms of the herbaceous production the upland sagebrush shrublands tend to be the most productive, followed by the chained rangelands, pinyon- juniper woodlands and bottomland sagebrush shrublands.

Differences Related to Development Effects. In 1977 there were no significant differences between Plots 1-F and 2-F or 5-F and 6-F (Table 8.7.2-3). Production was very low at all of the intensive study sites. In the pinyon-juniper woodland plots, the production was greater at Plot 6-F than at Plot 5, but the difference was not significant. Throughout the baseline period Plot 6 was more productive than Plot 5. This trend was also apparent in 1978 when the difference between Plots 5 and 6 was significant. It is highly doubtful that this difference is related to any development activities. It is most likely related to inherent site differences between Plots 5 and 6. Plot 5 occurs on dry east-facing slope and Plot 6 occurs on a ridgetop where soil and moisture conditions are apparently more favorable.

Table 8.7.2-2 . One-way analysis of variance results for comparisons of production among vegetation types, 1977 and 1978. Underlined plots are those with the significantly greater production.

	Calculated F	ν_1	ν_2	Critical Region $\alpha = 0.10$ F>	Significance*
DIFFERENCES AMONG VEGETATION TYPES-1977					
Chained Rangeland vs. Pinyon-Juniper					
1-F July vs. 5-F May	20.774	1	98	2.764	SIG
1-F July vs. 6-F July	18.497	1	98	2.764	SIG
2-F May vs. 5-F May	22.619	1	98	2.764	SIG
2-F May vs. 6-F July	20.776	1	98	2.764	SIG
Upland Sagebrush vs. Pinyon Juniper					
3-F May vs. 5-F May	223.214	1	98	2.764	SIG
3-F May vs. 6-F July	203.364	1	98	2.764	SIG
Bottomland Sagebrush vs. Pinyon-Juniper					
4-F July vs. 5-F May	4.044	1	98	2.764	SIG
4-F July vs. 6-F July	4.729	1	98	2.764	SIG
Upland Sagebrush vs. Chained Rangeland					
3-F May vs. 1-F July	40.586	1	98	2.764	SIG
3-F May vs. 2-F May	17.279	1	98	2.764	SIG
Bottomland Sagebrush vs. Chained Rangeland					
4-F July vs. 1-F July	31.709	1	98	2.764	SIG
4-F July vs. 2-F May	32.487	1	98	2.764	SIG
Upland Sagebrush vs. Bottomland Sagebrush					
3-F May vs. 4-F July	212.209	1	98	2.764	SIG
DIFFERENCES AMONG VEGETATION TYPES-1978 (Based on Range Cages)					
Pinyon-Juniper vs. Chained Rangeland	7.464	1	16	3.05	SIG
Pinyon-Juniper vs. Upland Sagebrush	12.914	1	17	3.03	SIG
Pinyon-Juniper vs. Bottomland Sagebrush	1.622	1	17	3.03	NS
Chained Rangeland vs. Upland Sagebrush	0.067	1	17	3.03	NS
Chained Rangeland vs. Bottomland Sagebrush	4.598	1	17	3.03	SIG
Upland Sagebrush vs. Bottomland Sagebrush	8.154	1	18	3.01	SIG

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* NS = Not significant
SIG = Significant

Table 8.7.2-3

One-way analysis results for comparisons evaluating development effects at Plots 1,2,5, and 6 and potential pollution effects north of Piceance Creek. Underlined plots are those with the significantly greater production.

	Calculated F	ν_1	ν_2	Critical Region α = 0.10 F>	Significance*
DEVELOPMENT EFFECTS - 1977					
1-F July vs. 2-F May	0.883	1	98	2.764	NS
5-F May vs. 6-F July	0.066	1	98	2.764	NS
DEVELOPMENT EFFECTS - 1978					
1-F vs. 2-F	2.725	1	98	2.764	NS
5-F vs. 6-F	59.302	1	98	2.764	SIG
POTENTIAL POLLUTION EFFECTS - 1978					
Pinyon-Juniper north of Piceance Creek, Treatment vs. Control Fenced	0.124	1	18	3.01	NS
Pinyon-Juniper north of Piceance Creek, Treatment vs. Control Open	1.652	1	18	3.01	NS

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* NS = Not Significant
SIG = Significant

ν_1 is the degree of freedom for numerator
ν_2 is the degree of freedom for denominator

There was no significant difference between the affected area site and control site in the potential pollution study area north of Piceance Creek (Table 8.7.2-3). This is to be expected inasmuch as no emissions yet exist. Tests were conducted on both the data from the range cages and data from the open areas. Neither were significantly different. It is fortunate that the control and affected area sites are so similar. Future comparisons will be more easy to conduct than if the sites were drastically different.

Differences Among Years. In the pinyon-juniper woodlands 1975 and 1976 were both significantly more productive than 1977 (Table 8.7.2-4), and 1978 was significantly more productive than 1975, 1976, and 1977 in all cases except for Plot 5 where the difference between 1975 and 1978 was not significant. The most dramatic differences occurred between the years 1977 and 1978. 1977 was a very dry year and 1978 was one of the most moist.

In the chained rangelands the differences among years were similar to those observed for the pinyon-juniper woodlands. 1975 and 1976 were significantly more productive than 1977, and 1978 was significantly more productive than 1976 and 1977, except at Plot 1 where the difference between 1976 and 1978 was not significant. Differences between 1975 and 1978 were not consistent. In some Plots, 1975 was significantly more productive and other cases 1978 was more productive.

In the upland sagebrush shrublands the same pattern was observed. 1975 and 1976 were significantly more productive than 1977, and 1978 was significantly more productive than 1976 and 1977. The difference between 1975 and 1978 was not significant.

For the bottomland sagebrush shrublands the yearly differences were the same as those observed in the upland sagebrush shrublands (Table 8.7.2-4).

The significant differences between years emphasize the importance of yearly changes in precipitation, and point to the responsiveness of the vegetation. The species are adapted to withstand dry years and grow only to a limited extent. In moist years these same species have the ability to produce more than five times the amount produced during a dry year.

Evaluation of Utilization. During the baseline period utilization was observed to be occurring early in the growing season and then again late in the season. For the middle part of the summer the livestock were grazing at elevations higher than the Tract. A similar pattern was observed during 1977 (Table 8.7.2-5). In May the differences between open and fenced plots were either not significant or the fenced plots were greater, except for Plot 6. In June half of the fenced plots were more productive and half were either more productive in the open plots or were not significantly different. By July the only significant difference was measured at Plot 1 where the fenced plot was more productive, suggesting that by the time of clipping in late July the open areas and fenced areas had mostly equalized in terms of herbaceous production.

Table 8.7.2-4 . One-way analysis of variance results for comparisons of production among years 1975-1978. Underlined years in each pair is the year with the significantly greater production.

	Calculated F	ν_1	ν_2	Critical Region $\alpha = 0.10$ F>	Significance*
DIFFERENCES AMONG YEARS					
Pinyon-Juniper Woodland					
1975 Plot 5 Combined Data vs. 1977 Plot 5 May	53.214	1	68	2.785	SIG
1976 Plot 5 Combined Data vs. 1977 Plot 5 May	7.121	1	77	2.777	SIG
1977 Plot 5 May vs. 1978 Plot 5	29.365	1	98	2.764	SIG
1975 Plot 6 Combined Data vs. 1977 Plot 6 July	31.082	1	68	2.785	SIG
1976 Plot 6 Combined Data vs. 1977 Plot 6 July	28.721	1	77	2.777	SIG
1977 Plot 6 July Data vs. 1978 Plot 6 Data	171.716	1	98	2.764	SIG
1975 Plot 5 Combined Data vs. 1978 Plot 5	1.153	1	68	2.785	NS
1976 Plot 5 Combined Data vs. 1978 Plot 5	6.353	1	77	2.777	SIG
1975 Plot 6 Combined Data vs. 1978 Plot 6	5.016	1	68	2.785	SIG
1976 Plot 6 Combined Data vs. 1978 Plot 6	26.604	1	77	2.777	SIG
Chained Rangeland					
1975 Plot 1 Combined Data vs. 1977 Plot 1 July	82.676	1	67	2.765	SIG
1976 Plot 1 Combined Data vs. 1977 Plot 1 July	10.635	1	77	2.777	SIG
1977 Plot 1 July Data vs. 1978 Plot 1	46.198	1	98	2.764	SIG
1975 Plot 2 Combined Data vs. 1977 Plot 2 May	13.951	1	68	2.785	SIG
1976 Plot 2 Combined Data vs. 1977 Plot 2 May	6.786	1	77	2.777	SIG
1977 Plot 2 May Data vs. 1978 Plot 2 Data	32.280	1	98	2.764	SIG
1975 Plot 1 Combined Data vs. 1978 Plot 1	12.088	1	67	2.785	SIG
1976 Plot 1 Combined Data vs. 1978 Plot 1	1.659	1	77	2.777	NS
1975 Plot 2 Combined Data vs. 1978 Plot 2	7.397	1	68	2.785	SIG
1976 Plot 2 Combined Data vs. 1978 Plot 2	0.001	1	77	2.777	NS

Table 8.7.2-4 . (Continued)

	Calculated F	ν_1	ν_2	Critical Region $\alpha = 0.10$ F>	Significance*
Upland Sagebrush					
1975 Plot 3 Combined Data vs. 1977 Plot 3 May	101.372	1	68	2.785	SIG
1976 Plot 3 Combined Data vs. 1977 Plot 3 May	8.662	1	77	2.777	SIG
1977 Plot 3 May Data vs. 1978 Range Cages	106.954	1	58	2.795	SIG
1975 Plot 3 Combined Data vs. 1978 Range Cages	0.161	1	28	2.890	NS
1976 Plot 3 Combined Data vs. 1978 Range Cages	27.369	1	37	2.852	SIG
Bottomland Sagebrush					
1975 Combined Data Plot 4 vs. 1977 Plot 4 July	35.350	1	68	2.785	SIG
1976 Combined Data Plot 4 vs. 1977 Plot 4 July	17.940	1	77	2.777	SIG
1977 Plot 4 July vs. 1978 Range Cages	85.918	1	58	2.795	SIG
1975 Plot 4 Combined Data vs. 1978 Range Cages	0.254	1	28	2.890	NS
1976 Plot 4 Combined Data vs. 1978 Range Cages	7.332	1	37	2.852	SIG

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* NS = Not Significant
SIG = Significant

γ_1 = degrees of freedom for numerator
γ_2 = degrees of freedom for denominator

Table 8.7.2-5 . One-way analysis of variance results for comparison of production in open and fenced plots, 1977 and 1978. Underlined plots are those with the significantly greater production.

	Calculated F	ν_1	ν_2	Critical Region $\alpha = 0.10$ F>	Signif-icance*
DIFFERENCES IN UTILIZATION					
May 1977					
1-0 vs. 1-F	0.669	1	98	2.764	NS
2-0 vs. 2-F	4.024	1	98	2.764	SIG
3-0 vs. 3-F	69.473	1	98	2.764	SIG
4-0 vs. 4-F	0.470	1	98	2.764	NS
5-0 vs. 5-F	1.018	1	98	2.764	NS
6-0 vs. 6-F	22.204	1	98	2.764	SIG
June 1977					
1-0 vs. 1-F	3.657	1	98	2.764	SIG
2-0 vs. 2-F	5.326	1	98	2.764	SIG
3-0 vs. 3-F	5.851	1	98	2.764	SIG
4-0 vs. 4-F	0.210	1	98	2.764	NS
5-0 vs. 5-F	10.671	1	98	2.764	SIG
6-0 vs. 6-F	15.438	1	98	2.764	SIG
July 1977					
1-0 vs. 1-F	3.555	1	98	2.764	SIG
2-0 vs. 2-F	0.237	1	98	2.764	NS
3-0 vs. 3-F	0.503	1	98	2.764	NS
4-0 vs. 4-F	0.012	1	98	2.764	NS
5-0 vs. 5-F	0.016	1	98	2.764	NS
6-0 vs. 6-F	1.763	1	98	2.764	NS
1978 - Based on Range Cage Data					
Pinyon-Juniper Fenced vs. Pinyon-Juniper Open	2.591	1	16	3.05	NS
Chained Rangeland Fenced vs. Chained Rangeland Open	0.414	1	16	3.05	NS
Upland Sagebrush Fenced vs. Upland Sagebrush Open	2.413	1	18	3.01	NS
Bottomland Sagebrush Fenced vs. Bottomland Sagebrush Open	5.203	1	18	3.01	SIG
Pinyon-Juniper north of Piceance Creek, Treatment Site Open vs. Fenced	3.415	1	18	3.01	SIG
Pinyon-Juniper north of Piceance Creek, Control Site Open vs. Fenced	14.710	1	18	3.01	SIG

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* NS = Not Significant, SIG = Significant

γ_1 = degrees of freedom for numerator ; γ_2 = degrees of freedom for denominator

In 1978 the only significant differences noted between range cage data and data from open areas were in the bottomland sagebrush shrubland type and in the control and affected area sites north of Piceance Creek. Differences in the pinyon-juniper woodlands on the Tract were not significant.

8.7.2.6 Conclusions

Several conclusions can be reached from the preliminary monitoring data.

1. The production patterns within vegetation types observed during monitoring period are the same as those observed during the baseline period.

2. Utilization continues to be seasonal and by mid-growing season is nearly non-detectable because of livestock use patterns.

3. Observed differences between intensive study Plots 1-F and 2-F, and 5-F and 6-F appear to be more related to site differences than to any development related activities.

4. Herbaceous production is closely related to precipitation. Significant differences between years are related to differences and fluctuating patterns of precipitation in this semi-arid region.

5. Fertilization of upland chained areas appears to result in an increase in herbaceous production. Because of a limited sample size and high data variability the differences between fertilized areas and control areas were not significant.

8.7.3 Shrub Production and Utilization

8.7.3.1 Scope and Rationale

Shrub production and utilization is measured each year to determine growth and utilization.

8.7.3.2 Objective

The main objectives for measuring shrub production and utilization were to correlate browse available and consumed by herbivores. over time and between stations.

8.7.3.3 Experimental Design

Production and utilization of bitterbrush were estimated along twelve transects on Tract during 1977-78 period. These transects were the same as those used for deer pellet-group studies and, consequently, transect notations were the same for both studies. Browse studies were also conducted on Big Jimmy ridge west of the tract, and although the same transects were again used for both pellet count and browse studies, browse evaluation methods differ on Big Jimmy ridge. On tract, the lengths of new shoots in fall and spring were measured to provide production and utilization estimates. On Big Jimmy ridge, utilization was found to be so severe that current shoot growth and the consumption of this growth by deer could not be evaluated by shoot measurements. In many instances, shrubs were browsed back into the growth of the previous year. The information obtained for Big Jimmy ridge, therefore, concerns shrub density, reproduction, and vigor evaluations rather than production and utilization. Also, on Big Jimmy mountain mahogany as well as bitterbrush was sampled. Utilization of sagebrush was measured on all 27 deer pellet-group transects. Ocular estimates were made using pace transects and recording age and degree of hedging for each plant. An angle gauge was used to estimate sagebrush density on each transect.

8.7.3.4 Method of Analysis

Analysis performed included 1) correlation with past deer data, and 2) professional judgment.

8.7.3.5 Results and Discussions

Production and utilization estimates of bitterbrush and mountain mahogany for this past year differed markedly from 1976-77 estimates in that production was lower and utilization was much higher. Yearly patterns of mule deer habitat use as revealed by these data are not as similar as patterns revealed by pellet-group data. The 1977 production estimates for the twelve transects on tract (Tables A8.7.3-1 to -4) vary considerably from one location to another. The percent utilization estimates, in contrast, are comparatively uniform. For most transects, utilization was near the 90 percent level. This represents severe utilization, which appears to have been due mainly to a large deer herd and to low shrub production the previous year.

Trends in shrub production and utilization are shown on Figure 8.7.3-1. The low productivity and the high utilization which occurred during the 1977-78 period are clearly evident. A correlation coefficient was calculated to determine the intensity of association between the utilization estimates for the 1976-77 and 1977-78 periods. A low correlation was found to exist between the values obtained for the two years at the same transect locations (r=0.4; which is significant at the 80 percent level).

Only production data are available for the 1977-78 period (Table A8.7.3-5) since spring estimates of utilization have not yet been obtained. Bitterbrush and mountain mahogany evaluations for Big Jimmy ridge (Tables A8.7.3-6 and -7) represent the first year of browse data for this locality. As previously described, production and utilization estimates were not made because of severe utilization coupled with meager shrub production. A visual examination of production this past spring, however, indicates that shoot measurements will probably be feasible next year.

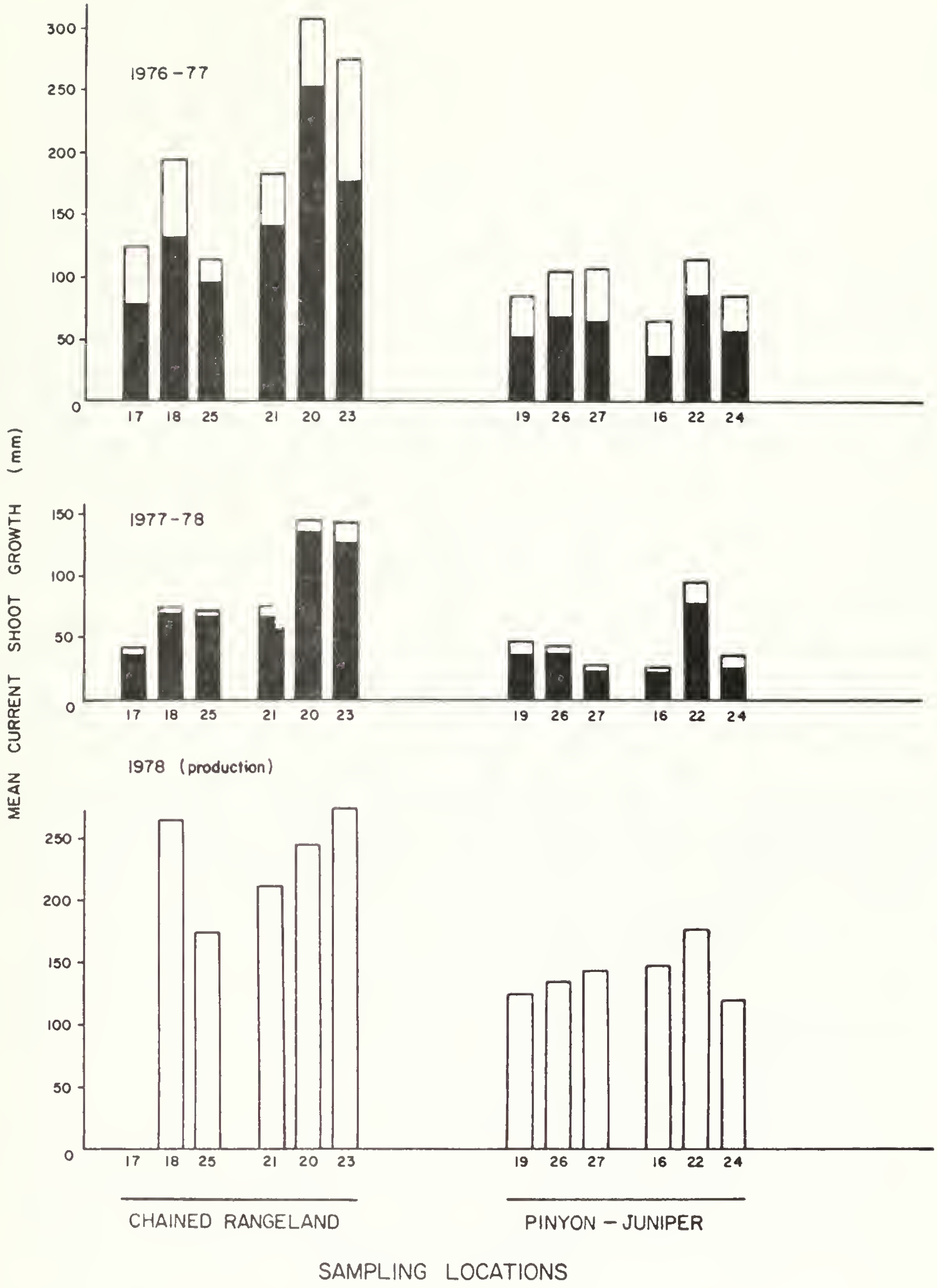


Fig. 8.7.3-1 Trends in production and utilization of bitterbush. Shaded areas and figures represent the percent of current shoot growth consumed by deer. Transect numbers are indicated below bars.

The 1978 sagebrush ocular estimate data are presented in Table A8.7.3-8. This is the first year ocular estimates were used, therefore, several years data are needed before any statistical analysis can be performed. Information will be compared to other sources, Division of Wildlife and Bureau of Land Management, when it becomes available. Data from transects located in chained pinyon-juniper show more mature plants, less heavy use, and greater density than the sagebrush in the pinyon-juniper. This is not surprising since one would expect heavier use on individual browse plants in areas with a low browse density than in areas with a high browse density.

Several different applications of fertilizer were applied during the spring of 1978 on six browse transects. Four new transects and two of the original monitoring transects were used for these experiments. Preliminary results (Table A8.7.3-9) were compared with production estimates elsewhere in chained rangeland habitat (Tables A8.7.3-1 and A8.7.1-3), indicate little if any enhancement in production after the first five months. Six pairs of control and experiment transects were evaluated. Five of these showed higher production values for the control transects. The one pair of transects with higher production in the experimental location (BA31 and BA21) was subjected to a onetailed t-test. The difference between these two transects was found to be significant ($P<0.05$).

8.7.4 General Vegetation Condition Studies

This study begins in 1979 and will be reported in the next Annual Report, April 1980.

8.7.5 Micro-Climatic Studies

8.7.5.1 Scope and Rationale

Studies on micro-climatic parameters on the C-b Tract provide data that are useful in assessing changes in vegetation production and structure, animal populations, or animal activity patterns, and may also be correlated with changes in functional components of the C-b ecosystem that may occur as a result of shale oil development.

8.7.5.2 Objectives

In order to define changes in plant growth and wildlife populations the micro-climatic parameters which affect plant growth and wildlife populations are studied.

8.7.5.3 Experimental Design

Five micro-climatic stations are located in development sites and five in control sites. The locations of these ten sites (see Sta BC01-09, 13 on the jacket map) are the same as baseline locations. Therefore, data from March 1975 through the present can be compared. Each station is monitored twice monthly for the following parameters:

Mc Station Locations

BC01	Chained Pinyon-juniper Rangeland, Veg. Plot 1
BC02	Chained Pinyon-juniper Rangeland, Veg. Plot 2
BC03	Plateau Sagebrush, Veg. Plot 3
BC04	Valley Bottom Sagebrush, Veg. Plot 4
BC05	Pinyon-juniper Woodland, Veg. Plot 5
BC06	Pinyon-juniper Woodland, Veg. Plot 6
BC07	Chained Pinyon-juniper Rangeland (Animal Trapping Transect)
BC08	Bunchgrass Community, South-facing Slope
BC09	Valley Bottom Sagebrush, Mouth of Sorghum Gulch
BC011	Mixed Mountain Shrubland, North-facing Slope

Parameters

Air Temp.: 1 m
Soil Temp.: Surface
Precipitation
Snow Depth and
Moisture Content

All temperature readings consist of maximum and minimum readings for two-week periods. Precipitation is measured only during the growing season, March through October. Therefore, precipitation data from meteorology stations 020 and 023 are utilized for winter-month readings (November - February) for valley and pinyon-juniper microclimate stations. Snow measurements are obtained approximately from November - February.

8.7.5.4 Methods of Analysis

Methods of analysis include times series plots of precipitation and snow depth (Figures B8.7.5-1 thru -10), max. and min. temperature (Figures B8.7.5-11 thru -20), and correlations with plant and wildlife data. The reader should also consult Climatological Records, Section 6.3.1, for additional tables, time series plots, and histograms.

8.7.5.5 Results and Conclusions

Precipitation was notably higher in 1978 than previous years (See Table A6.3.1-6a thru -6d). Precipitation was slightly higher than other sites at Pinyon-juniper Woodland and Upland Sagebrush sites. Herbaceous productivity was also significantly higher in 1978 than previous years. Also, the two sites which received slightly more precipitation were also the most productive.

Precipitation distribution was also more favorable during 1978 than 1977. (See Fig. 6.3.1-3, Table 6.3.1-3 and Tables A6.3.1-6a thru -6d). January, February, March, and April are important for herbaceous productivity and in 1978 they were much more favorable than 1977. May and June are the most active growth periods; consequently in 1978 the precipitation was heavy and the herbaceous productivity was also high. In 1977, the only heavy storm was in July when vegetative growth was nil due to the dry conditions.

Temperature dropped to near 0° C over the growing season, but did not seem to be a limiting factor as it was in 1976 when a killing frost in the middle of

June decreased total yearly vegetative productivity.

8.8 Threatened and Endangered Species

The bald eagle was observed several times in the tract vicinity. The raptors were not seen in any present or future development areas, or on Tract C-b. The eagles did not nest nor remain in the area; they were just flying through. Since the area is unsuitable bald eagle habitat and the eagles were just passing through, no further action will be taken except for continued monitoring for bald eagles.

No threatened or endangered plants were found on or near Tract C-b. A permanent herbarium has been established on tract and new plants will be continually added to it as they are found.

In conjunction with the numerous biological studies that will be conducted on and near Tract C-b during all parts of the year, observations confirmed by staff field biologists of any threatened or endangered species will be reported to the AOSO. Appropriate studies to determine significance of a sighting will then be initiated as determined jointly by C-b personnel and AOSO.

8.9 Revegetation

Revegetation monitoring will be conducted on sites which have undergone surface disturbance and on raw shale disposal sites. Revegetation monitoring will be conducted on areas larger than one acre which are seeded with the permanent seed mixture. This monitoring has been completed on sites which meet this criteria and will begin when permanent revegetation projects are completed.

8.9.1 Demonstration Plot

Because of delays in the development schedule the demonstration plot for 1979 will be built in 1980 with shaft oil shale.

9.0 ITEMS OF AESTHETIC, HISTORIC, OR SCIENTIFIC INTEREST

9.1 Aesthetic Values

The C-b Annual Summary & Trends Report (Nov. '74 through Oct. '75) described a study which determined the type and quality of scenic resources in the Tract area. It was concluded that the Piceance Creek Basin has a low scenic value when compared to the other landscape types of the region. Or restated, on a regional basis the Piceance Creek Basin has an extremely low visual character. Nonetheless, actions occurring in the past year include: a) cut-and-fill slopes were laid back and seeded according to the approved monitoring plan; b) buildings have been painted to B.L.M. standards; c) on-site power-line poles are green in color; and d) the main access road was laid out in such a way as to reduce aesthetic impact.

9.2 Historic and Scientific Values

A detailed baseline study of the cultural resources of Tract C-b has been conducted to identify sites of past human activity. (See Volume 1 of the Final Report of the Environmental Baseline Program.) It was concluded that three historic sites do exist on the Tract, (5RB136, 5RB146, and 5RB147) and will be investigated further prior to any development which would disturb them. During the past year, an archaeological team investigated the route for a planned 138 kv powerline from Meeker to C-b Tract. See Figure 9.2-1 for the planned route. No historic sites or remains were located. However, one prehistoric site and five isolated finds were located on or near the powerline right-of-way. Mitigation will be accomplished by avoiding these sites through minor rerouting of the right-of-way.

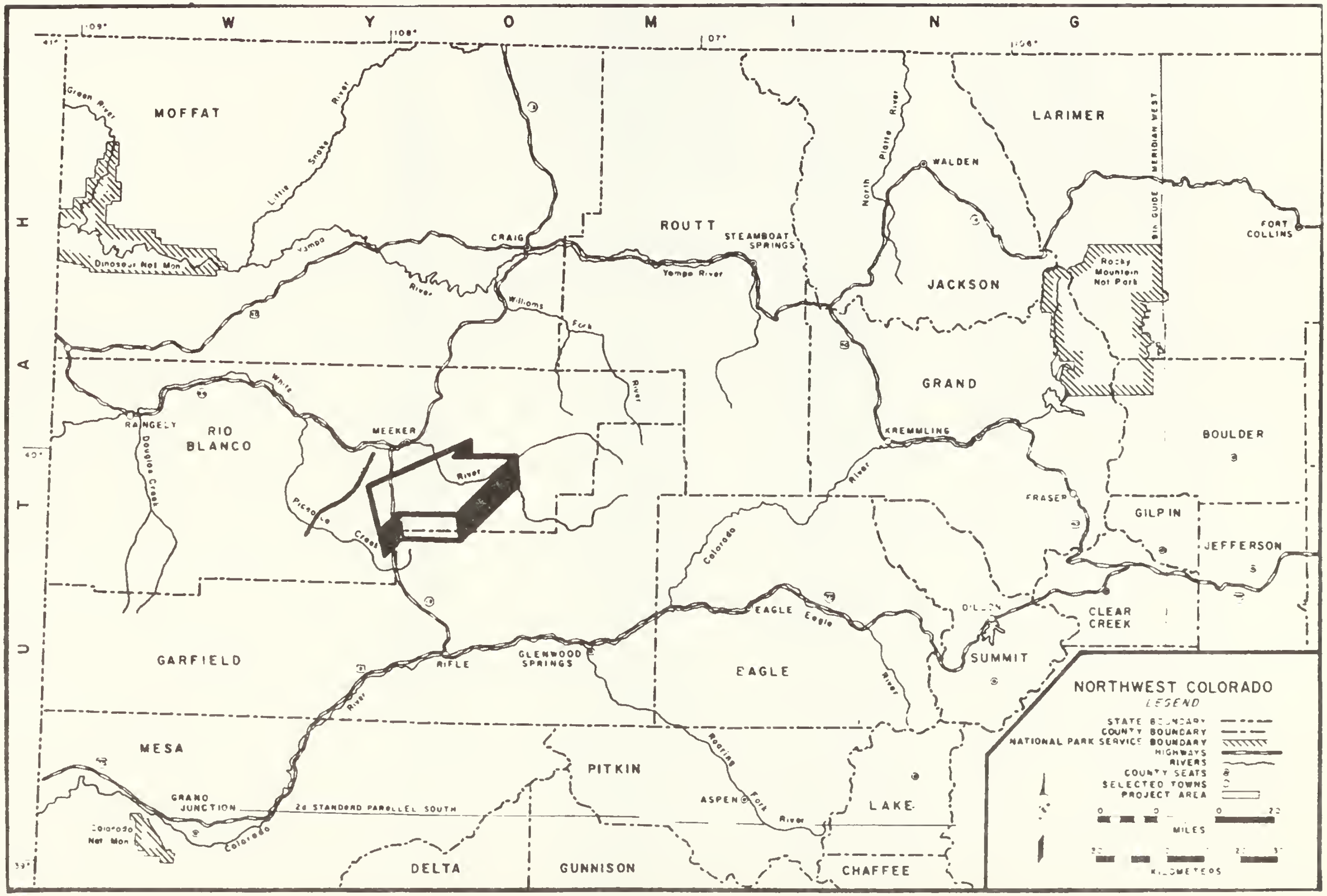


Figure 9.2-1 Planned Powerline Route from Meeker to the C-b Tract

10.0 INDUSTRIAL HEALTH AND SAFETY

10.1 Scope and Rationale

Periodic reports on Health and Safety Activities have been requested by the Area Oil Shale Supervisor. Such reports are those prepared by the C-b Project and all contractors for distribution to outside Federal and State agencies, i.e., Mine Safety and Health Administration (MSHA) and the Colorado Division of Mines and inspection reports made by these agencies and received by the Project and all contractors at the C-b site.

These reports relate to accident frequency analyses, inspection reports and responses, health and safety training, and variance reporting. As received, they are included in the semi-annual data reports.

The C-b project is regulated under the new code of Federal Regulations, Title - 30, Part 57, Mine, Safety, Health Administration. We are also governed by the Colorado State Division of Mines laws.

All Contractors on the C-b Site are monitored by the Occidental Safety Department through Ralph M. Parsons Co., our Managing Contractor.

10.2 Accident Frequency Analysis

We have three mine I.D. Numbers on the C-b Site. They are as follows:

1.	Occidental Oil Shale	05-03140
2.	Ralph M. Parsons	05-03148
3.	Gilbert Corp. of Delaware	05-03149

Each I. D. Number is responsible for their own Accident/Incident frequency and severity rate.

Using the MSHA formulas,

$$\text{I.R.} = \text{Injury Rate} = \frac{\text{Number of Accidents X 200,000}}{\text{Hours of Employee Exposure}}$$

$$\text{S.M.} - \text{Severity Measure} = \frac{\text{Days Lost Time X 200,000}}{\text{Hours of Employee Exposure}}$$

the breakdown of accident and severity rate by I. D. Number is as follows:

I.D. # 05-03140 - One lost time accident in 48,988 manhours, resulting in 5 lost time days. This accident resulted in an I.R. = 4.08, for which S.M. = 20.41.

I.D. #05-03148 - This I.D. carries all contractors other than Occidental and Gilbert Corp. They accounted for 2 lost time accidents in 276,166 manhours for an I.R. of 1.44. The 2 accidents resulted in 2 lost time days, thus S.M. = 1.44.

I.D. # 05-03149 - Gilbert Corp. has had no lost time accidents in 117.064 manhours.

The three I.D. Numbers logged 442,218 manhours in 1978 with 3 lost time accidents totaling 7 lost time days for a site I.R. of 1.35 and S.M. of 3.16. Compared to the 1978 national average for underground mines (I.R. - 16.32, S.M. = 23) we have an excellent safety record and plan to improve it in the coming year.

10.3 Inspection Reports & Responses

We have had only 1 MSHA inspection in the past year. It resulted in two minor citations. Colorado Division of Mines inspected the property eight times during 1978. They wrote 18 citations; all citations were abated on the same day they were written.

11.0 SUBSIDENCE MONITORING

The overall objective of the subsidence monitoring program is to determine the effects of underground excavations on the ground surface and on in-situ mining levels.

The surface and underground subsidence caused by mining activities cannot start until significant underground development out from the shaft pillar areas occurs.

The inventory of physical features of the site is being carried out under the aerial photography program described in Section 3.3 of this report.

12.0 ECOSYSTEM INTERRELATIONSHIPS

12.1 Introduction

Indicator variables for Development Monitoring are given in the Development Monitoring Plan. Also listed are perturbations that affect the magnitude of these variables and the environmental consequences (or impacts) of these perturbations. Examples of perturbations include mining, retorting, shale disposal, waste disposal, etc. Environmental consequences may affect other indicator variables; such relations of indicator variables with other indicator variables are to be analyzed and are called ecosystem interrelationships.

Ecosystem interrelationships are not monitored or measured directly. They are inferred from three principal techniques: 1) expert judgment resulting from baseline observations of two or more variables, 2) correlative statistics, and 3) predictive ecosystem modeling. Aspects of all three have been gleaned from the baseline studies and reported in Volume 5, System Interrelationships, Environmental Baseline Program Final Report and its Appendix F, User's Reference Diagrams (1977). In particular, baseline judgment has been utilized to obtain the comprehensive "effects matrix" (Figure A12.1-1).

With regard to the comprehensive "effects matrix." so-called effect generators (driving variables, perturbations, state variables) are listed across the top (matrix columns) and effect receptors (abiotic and biotic components and processes) are listed at the side as matrix rows. Entries in the matrix are the following interrelationships: direct effects, indirect effects, both direct and indirect, and effects of particular concern. Forty-five (45) updated effects of particular concern have been transposed to Table 12.1-1 of this report.

The matrix will be periodically updated to include additional relationships needed to assess impacts of development.

The interrelationships of Table 12.1-1 and others defined as new monitoring results will be analyzed in the future and subjected to correlative statistical techniques as a means of defining those interrelationships of major concern. Subsequent monitoring can then concentrate on these.

12.2 "Candidate" Interrelationships

The above considerations provided insights into specific interrelationship "candidates" for early study. The screening consisted of three phases: (1) qualitative, (2) initial quantitative, and (3) refined quantitative.

The qualitative phase consisted in identifying the dependent variable(s) and all major independent variables, both natural and man-induced perturbations. Too many gaps in the data precluded quantitative analysis at this time. However, a purpose was still served in that it pointed the way for future increased sampling rigor and uniformity. Then, provided the data were deemed

TABLE 12.1-1 MAJOR ECOSYSTEM INTERRELATIONSHIPS

EFFECT GENERATORS / EFFECT RECEPTORS	PRECIPITATION	AIR TEMPERATURE	BORON (Water)	SO_2 (Air)	NO_x (Air)	OZONE (Air)	FLUORIDE (Water)	TRACE ELEM. (Air)	NOISE	DISTURBED VEG.	UNREVEG. BARE AREAS	EROSION	MIXED SOIL PROFILE	ALTERED SOIL CHEM.	SEDIMENT	ALTERED SURF. WATER FLOW	WATER TABLE ALTER.	ALTERED WATER QUAL.
RUNOFF	X										X	X			X			
STREAMFLOW												X					X	
GROUNDWATER FLOW																	X	
PLANT GROWTH	X	X	X	X	X	X	X	X						X		X		
LITTER DECOMP.				X														
ANIMAL GROWTH	X	X	X				X	X										
REPRODUCTION									X									
ANIMAL MOVEMENT									X									
AQUATIC PLANT GROWTH			X				X								X	X		X
AQUATIC VERT. GROWTH															X	X		X
AQUATIC VERT. MORT.																		X
AQUATIC INVERT. GROWTH															X	X		
AQUATIC INVERT. MORT.																		X
SOIL CHEM. & pH								X										
WATER QUALITY																	X	
ANIMAL TISSUE							X											
GEN. HABITAT									X	X	X							
REVEGETATION													X	X				

complete enough, quantitative analyses were attempted. Refined quantitative analyses will be undertaken in future years.

At this writing three candidates have "survived" the qualitative screen and initial quantitative analysis attempted. These are:

(1) Effects of climatic variations on herbaceous productivity. When the "land treatment" system is initiated its effects will be included.

(2) Effects of traffic on Piceance Creek road, snow depth, and deer population on deer road kill.

(3) Effects of "urbanization" (from unrevegetated or surfaced areas) on watershed hydrologic response time.

Other interrelationships subjected to qualitative study included:

(4) Effects of herbivore density on shrub utilization.

(5) Hunting and trapping pressure on coyote and rabbit interrelationship.

(6) Deer mortality vs. shrub production and utilization.

Increased sampling rigor and/or uniformity will be sought to enhance the possibility of quantitative results in the future.

These six "near-term" interrelationships are discussed in the following paragraphs:

12.3 Specific Near-term Interrelationships

12.3.1 Effects of Climatic Variations on Herbaceous Productivity

12.3.1.1 Qualitative Judgements

It is expected that herbaceous productivity increases with increasing precipitation and increased length of the growing season. Specific precipitation measures suggested are:

(1) total annual precipitation of the current year.

(2) total annual precipitation of the previous year, especially late season precipitation

(3) precipitation temporal distribution over
  (a) Mar - Apr - May or
  (b) Apr - May - June or
  (c) May - June - July or

(4) abnormal rates of precipitation

Growing season candidate variables include:

(1) length of the growing season

(2) total degree - days during the growing season

(3) degree - day temporal distribution over

  (a) Apr - May - June
  (b) May - June - July
  (c) June - July - Aug
  (d) July - Aug - Sept

12.3.1.2 Quantitative Analysis

It is instructive to point out that it is next to impossible to obtain a highly accurate total of annual precipitation in a harsh, remote area at any one site. Therefore, monthly average values in the Tract vicinity were obtained and summed over 12 months to obtain average annual totals in the Tract vicinity. Table 6.3.1-3 of Chapter 6 presents average annual total precipitation, with and without the microclimate stations (i.e. stations under canopies). Also presented on the same table are three-month "sliding" precipitation distribution and peak precipitation events. Figure 6.3.1-3 of Chapter 6 presents monthly precipitation histograms in combination with related growing season spans. Table A6.3.1-3 presents total degree-days, three month sliding degree-days and growing season dates and spans.

The following herbaceous productivity sites were selected for analysis:

BJ02 - Chained Pinyon Juniper (Control)
BJ05 - Pinyon Juniper Woodland (Future Development)

A simple tabular approach was utilized whereby for each of the four years productivity was ranked from highest to lowest (1 to 4 respectively) as were each of the remaining independent variables. Those coming closest to the productivity rank order are presented in Table 12.3.1-1. Degree-days did not correlate positively and are not shown; as a matter of fact, the year with the lowest productivity had the highest degree-days and the highest or second highest productivity year corresponded to the lowest degree-days.

Quantities which rank-correlated best with productivity and are plotted on Figure 12.3.1-1 are:

1) precipitation during April-May-June
2) precipitation of the previous year
3) length of the growing season
(with one anomaly - when it rained too late to be of use)

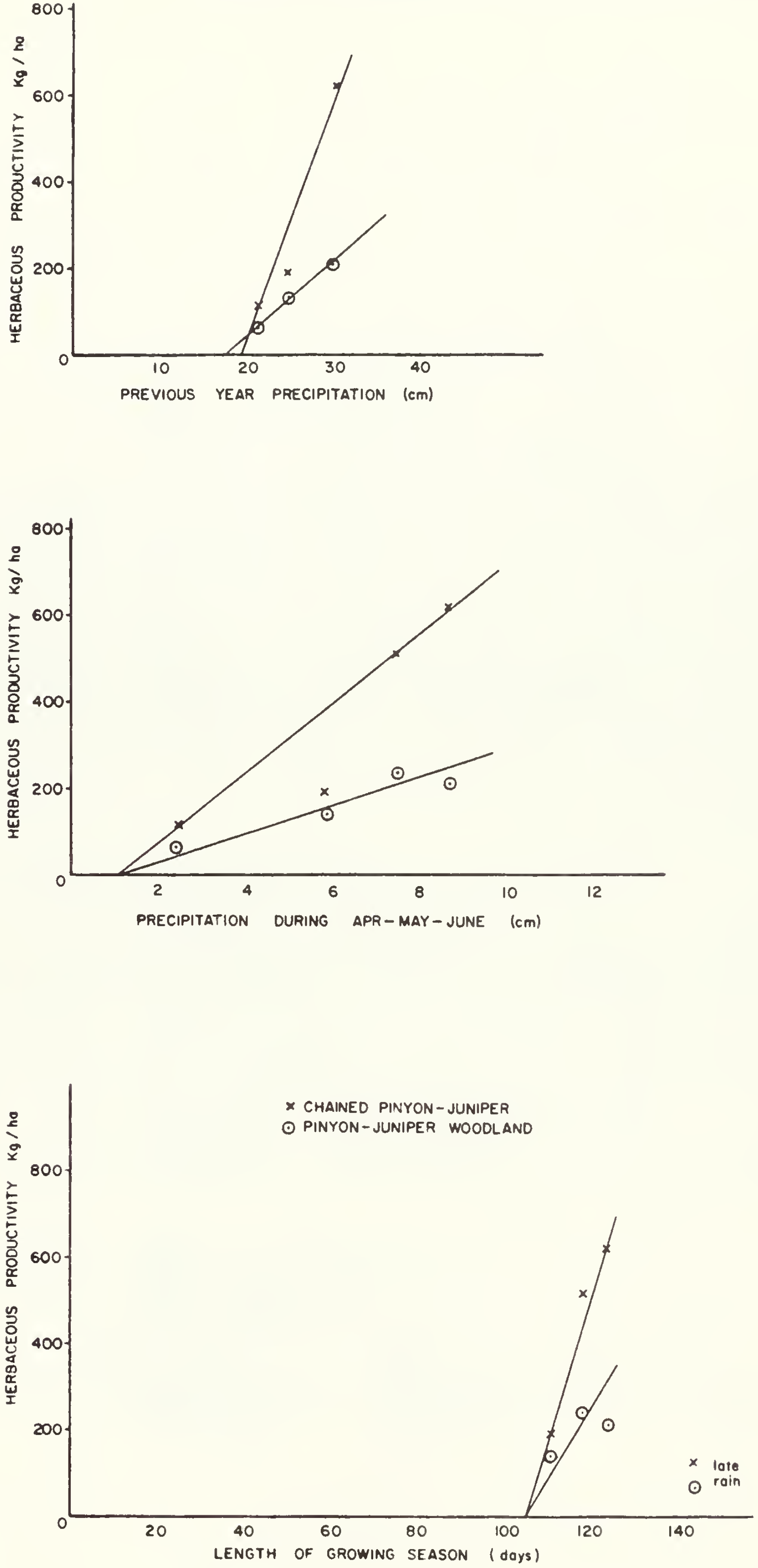
Statistical correlation and regression will be attempted at a future date.

TABLE 12.3.1-1 "RANKING" OF INDEPENDENT VARIABLES WITH PRODUCTIVITY

(1)→(4) = Rank from Top to Bottom

Site	Year	Productivity (kg/ha)	April-May -June Ppt (cm)	Total Ppt. of Previous Year (cm)	Growing Season (Days)
Chained Pinyon Juniper (BJ02) (Control)	1975	514 (2)	7.53 (2)	-	118 (3)
	1976	189 (3)	5.91 (3)	24.86 (2)	111 (4)
	1977	116 (4)	2.52 (4)	21.46 (3)	144 (1)
	1978	623 (1)	8.72 (1)	30.35 (1)	124 (2)
Pinyon Juniper Woodland (BJ05) (Future Development - Present Control)	1975	233 (1)			
	1976	134 (3)	as above	as above	as above
	1977	62 (4)			
	1978	210 (2)			

FIG. 12.3.1-1 HERBACEOUS PRODUCTIVITY vs GROWING SEASON & PRECIPITATION (1975 through 1978)



12.3.2 Effects of Traffic, Snow Depth and Deer Road Count on Deer Road Kill

12.3.2.1 Qualitative Judgments

The dependent variable in this interrelationship is the number of deer killed by vehicles. The independent variables include: traffic along the Piceance Creek highway, deer population and movements, and the climate as characterized by snow depth and precipitation or snowing rates. A total of 125 deer were killed along the Piceance Creek highway from September 1977 to May 1978. Traffic estimates have been difficult to obtain due to the inclement weather causing equipment failure (snowplows cutting road-counter hoses, etc.)

Some general observations are: more deer are killed during the fall migration and during the spring green-up than during the winter months. Fewer deer are killed under poor weather conditions, probably because vehicles are moving slower and there is less deer movement. Deer are killed over the entire length of the Piceance Creek highway.

12.3.2.2 Quantitative Analyses

12.3.2.2.1 Scope and Rationale

The specific factors which must influence deer road-kill include traffic along various segments of Piceance Creek Road, snow depth, precipitation, work force, weekly deer count and weekly deer road-kill. Interrelationships determined among these will be used in the formulation of mitigative measures. Annual monitoring begins in mid-September and ends in April or May when deer have migrated to the highlands.

12.3.2.2.2 Objectives

The objectives of this study are:

1. To evaluate the interrelationships of traffic load, mitigative measures, time of year, deer movements, and climate on deer road-kill.

2. Review existing monitoring efforts and determine how they may be improved.

3. Use information gained from study and analysis to formulate other possible mitigative measures.

12.3.2.2.3 Experimental Design

Weekly samplings of deer road count and road-kill are obtained each year beginning in mid-September and continuing through May. Tabulations are for one-mile intervals along the 41-mile stretch of Piceance Creek Road between Rio Blanco and White River City (Highway 64).

Traffic counters are placed across Piceance Creek Road near Rio Blanco and at White River City, at the access road entrances to C-b and C-a tracts, and across Piceance Creek Road between the access roads. A count of incoming vehicles (excluding buses) is kept at the C-b guard gate.

Precipitation measurements are recorded hourly at several stations on and near the tract. Snow depth measurements are taken bi-weekly starting on December 1. For this study precipitation measurements from station AB20 and snow depth measurements from stations BC08 and BC09 are used because these stations are near Piceance Creek Road.

Passenger buses run round trips for all work shifts between Rifle and the C-b tract and between Meeker and the C-b tract. Daily records are kept of the number of passengers and number of buses.

12.3.2.2.4 Method of Analysis

Data used in this study are from records beginning September 21, 1978 and ending March 16, 1979.

Scatter plots were used to identify possible correlations between the deer-kill as the response variable and deer road count, traffic, precipitation and snow depth as independent variables. All data were grouped and averaged to correspond with the weekly deer-kill records. These variables were further examined for potential interrelationships utilizing computer programs for partial correlations and multiple linear regression. Outputs of the programs provide analyses for evaluating statistical significance of these interrelationships and some of the outliers in the scatter diagrams. Outliers are data observations with extreme values relative to the remaining observations.

12.3.2.2.5 Results and Discussion

(a) Correlation Analyses

Scatter diagrams depicting the relationships between the study variables are shown in Figures A12.3.2-1, A12.3.2-2, A12.3.2-3, and A12.3.2-4.

Using the correlation coefficient (r) and converting to t-score by the formula

$$t_1 = r / ((1-r^2) / (n-2))^{\frac{1}{2}}$$

the results summarized in Table 12.3.2-1 were noted.

The correlation coefficients are lower than might be expected. The only significant correlation is that between deer road count and road kill. Correlations between deer-kill and precipitation and snow depth, although not significantly different than zero, are negative indicating a very weak inverse relationship and lend weak support to the qualitative observation that road-kills are fewer with poor weather conditions.

Table 12.3.2-1

SUMMARY OF CORRELATION ANALYSIS

1. deer kill vs. deer road count $r = 0.4064$
   $t_1 = 2.1331 > t\ (23,\ 0.95) = 2.064$* significant
2. deer kill vs. traffic $r = -0.2269$
   $t_1 = 1.1173 < t\ (23,\ 0.95) = 2.064$* not significant
3. deer kill vs. precipitation $r = -0.2064$
   $t_1 = 1.0116 < t\ (23,\ 0.95) = 2.064$* not significant
4. deer kill vs. snow depth not calculated because of low correlation
   $r = 0.0781$
   not significant

* t obtained from standard statistical table with 23 degrees of freedom and 95 percent confidence interval. If t_1 is greater than t, then the correlation between the two parameters is significant.

The correlations are influenced by a few outliers. In this case the outliers were high road-kill counts in March. These outliers are explained by the movement of the deer to the slopes when the snow starts to melt. The change in the weather also melts the ice off the road and results in increased traffic speed, a probable factor in the road-kill count.

(b) Regression Analyses

Multiple regression analyses were performed to obtain predictive relationships between the responsive variable, deer-kill, and the independent variables. These analyses were considered insignificant when relationships could not be clearly defined for snow depth, precipitation and traffic count. The correlation coefficient shows the relationship to deer count as the greatest. See Tables A12.3.2-1, A12.3.2-2, and A12.3.2-3. Using a backward elimination procedure with deer kill regressed on deer road count, traffic, and precipitation (as the independent variables), the results are shown in Table 12.3.2-2. This result is identical with results of the previous correlation analysis; i.e. deer kill correlated only with deer road count.

Table 12.3.2-2

SUMMARY OF REGRESSION ANALYSES

1. deer road count, traffic precipitation

   $F_1 = 1.6492 < 3.07 = F(3, 21, 0.95)^*$ not significant

2. deer road count, traffic

   $F_1 = 2.1803 < 3.44 = F(2, 22, 0.95)^*$ not significant

3. deer road count

   $F_1 = 4.5497 > 4.28 = F(1, 23, 0.95)^*$ significant

* F-statistic from standard statistical tables; if F_1 is greater than F then the result is significant.

The non-significant F-scores can be attributed to the lack of good traffic data. The best data and those used were from the guard gate count. Traffic monitors on Piceance Creek Road were frequently cut by snow plows in inclement weather.

(c) Other Analyses

Using deer count by mile, a ratio of deer kill to deer road-count was determined for three segments of Piceance Creek Road as shown in Table 12.3.2-3.

Table 12.3.2-3

SUMMARY OF DEER ROAD-COUNT AND ROAD-KILL BY ROAD SEGMENT

Road Segment	Road Kill	Road Count	Ratio	Percent of Traffic*
Rio Blanco to C-b	69	4527	0.0152	54%
C-b to C-a Access Road	13	1397	0.0093	incl.
C-a Access Road to White River City	21	1146	0.0183	13%
Rio Blanco to C-a Access Road	82	5924	0.0138	27%
Other Oil Shale Employee Traffic	incl.	incl.	--	6%
Other Piceance Creek Traffic	incl.	incl.	--	?

* Traffic based on combined C-a and C-b employee estimates of 446.
incl. - means included in other segments.

The low ratio of kill to road-count on the section of Piceance Creek Road between the C-a and C-b access roads can be explained by the terrain. The other two sections have gentler terrain on both sides of the road.

Bus passenger reports from September 1, 1978 to January 31, 1979 were summarized into round trips per week in Table 12.3.2-4.

Table 12.3.2-4

SUMMARY OF BUS STATISTICS

Total passengers for 21.86 weeks	23,340
Average passengers per week	1,068
Total bus trips for 21.86 weeks	524
Average bus trips per week	24

Although no prediction of deer saved is possible without adequate traffic data and passenger-per-vehicle data, it is apparent that a substantial number of passenger vehicle-round-trips per week are being saved through bus use. For example, the average number of passengers which ride the bus per week indicates a savings of 332 vehicle-round-trips per week, if there is an average of three passengers per vehicle. If there is one passenger per vehicle, a savings of 1044 vehicle-round-trips per week is the result of the bus service.

12.3.2.2.6 Conclusions and Recommendations

Based on the available data, the scatter diagrams, correlation, and regression analyses show the only variable influencing the number of deer killed was the deer road-count. Yet, it seems natural that deer road kill is related to traffic and hence the reduction of traffic by providing buses is a significant factor in reducing deer road-kill. Also, the climate, condition of deer killed, and location where deer are most likely to be on the road may be shown to be significant when better data are available. When any of these factors are found to be significant, additional mitigative measures may be formulated.

The following changes in the experimental design have been implemented or are recommended in order that the interrelationships with these variables and deer kill can be more accurately determined.

1. Starting in March 1979, the deer mortality reports will include a marrow condition. This may establish a relationship between deer condition and road kill.

2. Magnetic loop counters are being obtained to replace counter hoses as traffic monitors. These monitors will be placed at positions designed to relate traffic count to deer kill count by road segment.

3. Deer kill and traffic counts may be made daily for a short period of time to permit a more detailed study of the interrelationship. When traffic counts were averaged by week to correspond with weekly deer kill counts, daily variations in traffic count related to week-ends or holidays were lost.

4. An estimate of time of day deer are killed should be made when possible. Analysis of these data may indicate possible mitigative measures such as a change in hours at which shift changes occur.

5. From guard gate inquiries or employee surveys, an average number of passengers per vehicle should be obtained. This information could be used with employee route information determined from residence and bus service data to perform correlation studies of deer count and deer road kill with traffic.

6. Traffic speed controls should be considered during periods of high road kill and on road segments of high road kills.

It would appear that the implementation of the above additions to the experimental design will yield sufficient data to evaluate the interrelationships of traffic load, mitigative measures, time of year, deer movements, and climate, on deer road kill. With this knowledge additional mitigative measures might be formulated. If a quantitative relationship between increased traffic and road kill were determined, it would be possible to predict the number of deer which are saved by the bus service and any additional mitigative measures formulated.

12.3.3 Effects of Urbanization on Hydrologic Response Time

12.3.3.1 Scope and Rationale

Hydrologic response of a stream to a precipitation event or successive bursts of rainfall may be determined through comparison of the hyetograph and hydrograph produced by a given storm. A hyetograph is a plot of rainfall rate versus time. A plot of runoff rate versus time yields a hydrograph.

Precipitation which reaches the ground surface may infiltrate or flow over the land as runoff. Runoff contributed by various portions of the drainage basin will be incorporated into the hydrograph characteristic of a given point on the stream at different times. If the hyetograph and hydrograph are plotted on the same graph, the centroid lag, or lag time, can be determined. The lag time is the difference between times at which 50 percent of the total accumulation of both variables has occurred.

The lag time of a basin can be expected to decrease with increased urbanization. Paving, clearing and building could decrease infiltration and increase runoff and flood peaks.

12.3.3.2 Objectives

Although development of C-b Tract is anticipated to cause a minimum of surface disturbance, study of lag times throughout development may provide a measure of surface impact.

12.3.3.3 Experimental Design

Records of stream flow and precipitation for a storm on at least an hourly basis are necessary to determine lag times. Although gauging stations are equipped with continuous flow recorders, only daily-average flows are published. The USGS Water Resources Division in Meeker provides hourly values on request. Flow data for Stations WU61, WU58, WU42, WU39, WU36, and WU22 would be appropriate for studies of hydrologic response time. Station AB20, operated by C-b Tract, measures precipitation on an hourly basis during storms. Records of the amount of disturbance of Tract acreage on an annual basis are necessary to relate urbanization to hydrologic response time.

12.3.3.4 Method of Analysis

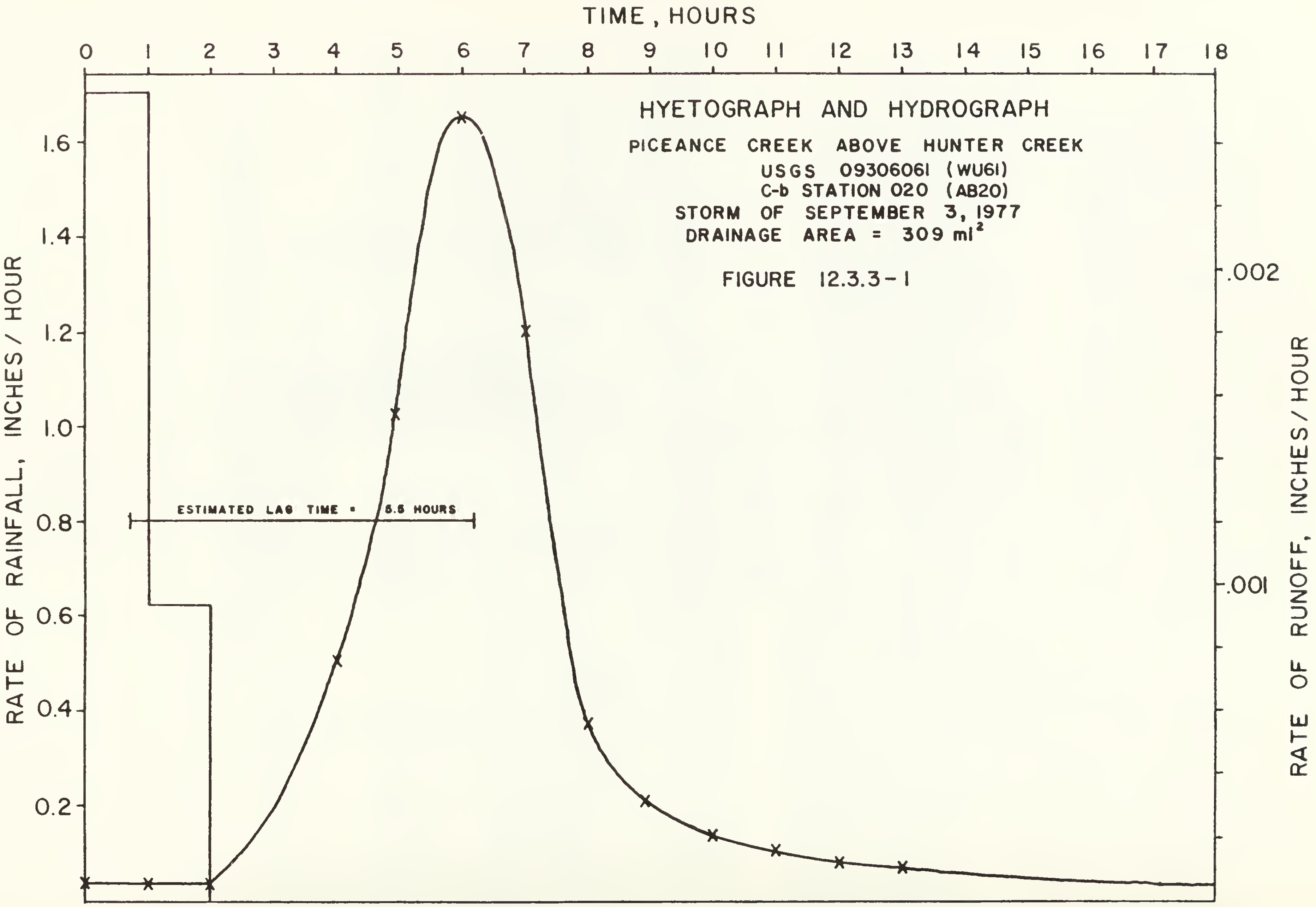
A high-intensity storm of brief duration on September 3, 1977 produced a flood with a flow in excess of any other flood since 1939 (information provided by a local resident). The hyetograph and hydrograph of the storm are plotted for data gathered at C-b Station AB20 and USGS Stream Gauging Station WU61, Piceance Creek above Hunter Creek (Figure 12.3.3-1). Rate of rainfall and rate of runoff are given in inches per hour (Table 12.3.3-1). Stream gauging records in cubic-feet per second are converted to inches per hour according to the relationship "one inch per hour from one acre equals one cfs".

Table 12.3.3-1

RAINFALL AND PRECIPITATION DATA

SEPTEMBER 3, 1977

Time	Hours Since Storm Inception	Discharge cfs	Runoff in./hr.	Rainfall in./hr
1100	0	9.6	0.00005	0
1200	1	9.6	0.00005	1.70
1300	2	10	0.00005	0.61
1400	3	55	0.00028	0
1500	4	150	0.00076	0
1600	5	305	0.00154	0
1700	6	480	0.00243	0
1800	7	355	0.00180	0
1900	8	113	0.00057	0
2000	9	63	0.00032	0
2100	10	41	0.00021	0
2300	12	25	0.00013	0
2400	13	22	0.00011	0



HYETOGRAPH AND HYDROGRAPH

PICEANCE CREEK ABOVE HUNTER CREEK
USGS 09306061 (WU61)
C-b STATION 020 (AB20)
STORM OF SEPTEMBER 3, 1977
DRAINAGE AREA = 309 mi^2

FIGURE 12.3.3-1

12.3.3.5 Results and Discussion

An estimate of the lag time of the drainage area upstream of the gauging station (309 sq. mi.) is approximately 5.5 hours. Additional storms will be studied to refine lag time estimates and to estimate possible future effects of urbanization on this parameter.

12.3.3.6 Conclusions

Although the Piceance Creek gauging station above Hunter Creek was used as an example, stations in the C-b Tract drainages should be evaluated for lag time as stream flow records lengthen to more accurately gauge possible effects of Tract development.

12.3.4 Effects of Herbivore Density on Shrub Utilization

12.3.4.1 Qualitative Judgments

The dependent variables are (cattle and deer) herbivore densities. Independent variables include: climate data, road counts, age and sex counts, shrub production and utilization results and lagomorph abundance. This information is gathered from developmental and control transects, micro-climate stations and various deer counts.

Some general conclusions that can be made at this time are:

* Cattle use has not changed appreciatively in the last four years.
* Mule deer road count studies showed a spatial seasonal pattern almost identical to the past three years of study.
* Baseline-condition evaluations of mule deer pellet-group distribution and density studies are continuing at this point in time. Transect locations which have been operative over the past two years have indicated very similar patterns of habitat use.
* Production and utilization estimates of bitterbrush and mountain mahogany for this past year differed markedly from 1976-77 estimates in that production was lower and utilization was much higher. Yearly patterns of mule deer habitat use as revealed by these data are not as similar as patterns revealed by pellet-group data.
* When precipitation decreased, browse production tends to decrease, but utilization tends to increase.

12.3.5 Hunter and Trapping Pressure on Coyote-Rabbit Interrelationships

12.3.5.1 Qualitative Judgments

Hunting and trapping pressure is the dependent variable which could influence coyote-rabbit interrelationships include raptor, small mammal, deer, coyote, and rabbit populations, and climate.

Conclusions to date are:

- There is very little rabbit hunting on or near the Tract.
- Coyotes were trapped in October in West Stewart Gulch.
- Raptor abundance has not changed significantly over the last four years.

Difficulties in quantifying hunting pressure exist. Intensified contacts to be pursued in this regard are Dept. of Wildlife and neighboring ranchers.

12.3.6 Deer Mortality versus Shrub Production and Utilization

12.3.6.1 Qualitative Judgments

Deer mortality is the dependent variable. Variables influencing deer mortality include: deer population and movements, climate, and shrub production and utilization.

Deer mortality data is collected on ten permanent study plots. Some general conclusions that can be made at this time are: past sampling showed that sampling in selected sagebrush draws was just as informative as sampling random plots in all habitat types on or around Tract C-b.

Since several new draws were added to the study since baseline, detailed analysis could not be done. Some results found this year were: (1) Possibly due to the mild winter, there were fewer dead deer per hectare than in previous years; (2) Fawns comprised 80% of the deer carcasses found this year.

13.0 NOTES

13.1 Conversion Factors

An attempt has been made to report all studies and data in metric units. In most cases these data are collected and initially tabulated in English units and a few analyses were carried out with English units. Table 13.1-1 contains conversion factors for converting from English to metric units. Conversion from metric to English units can be made by dividing by the factor or by multiplying by its reciprocal.

Table 13.1-2 presents additional conversion factors useful with interpretation of data reported herein.

13.2 Literature Cited

Table 13.2-1 is a bibliography of literature cited in the text. Reference in the text is by author or title.

Table 13.1-1

TABLE OF CONVERSION FACTORS

To Convert From	To	Multiply By
acres	ft^2	4.3560×10^4
acres	hectares	0.404687
atmospheres	dynes/cm^2	1.01325×10^6
atmospheres	bars	1.01325
atmospheres	mm H_g	760
atmospheres	newtons/m^2	1.01325×10^5
atmospheres	lbs/ft^2	2116.32
bars	atmospheres	0.98692
bars	mb	1000.00
bars	newtons/m^2	10^5
BTU (British Thermal Units)	gm. cal.	252.
cfm	liters/sec.	0.4720
cfs	m^3/s	0.028317
degrees Fahrenheit	degrees Kelvin	$(^{o}F-32)*(5/9)$ +273
degrees Fahrenheit	degrees Centigrade	$(^{o}F-32)*(5/9)$
degrees	radians	0.017453
feet	meters	0.3048
ft^2	meters	0.092903
ft^3/min.	m^3/sec.	0.000472
ft^3	gals	7.481
ft^3	m^3	0.028317
gals	m^3	0.0037854
gals	liters	3.7853
gals/min	m^3/sec.	0.00006309
gals/min	liters/sec.	0.069088
grains	grams	0.064798918
grains	pounds	1.42857×10^{-4}
hectares	m^2	10^4
inches	cm	2.5400
inch^3	cm^3	16.3872
miles	kilometers	1.60935
mph	mps	0.44703
pounds	kilograms	0.45359
pounds/acre	kg/ha	1.12173
pounds/hour	grams/sec.	0.1260
pounds/inch^2	atmospheres	0.068046
pounds/inch^2	mb	68.947
radians	degrees	57.29578
rods	meters	5.0292
SCFM (Standard Cubic Ft/Min)	ACFM (Actual cubic ft./min)	$(^{o}K_a/^{o}K_s)(P_s \text{ mb}/P_a \text{ mb})$
ton (short)	kilograms	907.185

Table 13.1-2

ADDITIONAL CONVERSION FACTORS
MULTIPLES AND SUBMULTIPLES OF UNITS

Factor by Which Unit is Multiplied	Prefix	Symbol
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	m
10^{3}	kilo	k
10^{2}	hecto	h
10	deka	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	µ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f

CONVERSION FACTORS FOR GASES

Molecular Weight (MW)	Pollutant	To Convert $\mu g/m^3$ at 25°C and 760 mmHg to ppb Multiply by Factor
46.01	NO_x as NO_2	.532
30.01	NO	.815
46.01	$NO_2=NO_x$ -NO	.532
64.06	SO_2	.382
34.08	H_2S	.718
-	THC	1.530
16.01	CH_4	1.525
28.01	CO	.873
48.00	O_3	.510

Equation: $$\frac{22.414}{MW}\left(\frac{298}{273}\right) = \text{Factor}$$

Table 13.2-1

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Volume 1 Regional and Temporal Setting. 221 pp.
Volume 2 Hydrology. 329 pp.
Volume 3 Meteorology, Air Quality, and Noise. 508 pp.
Volume 4 Ecology. 475 pp.
Volume 4 Ecology Appendices A & B. 509 pp.
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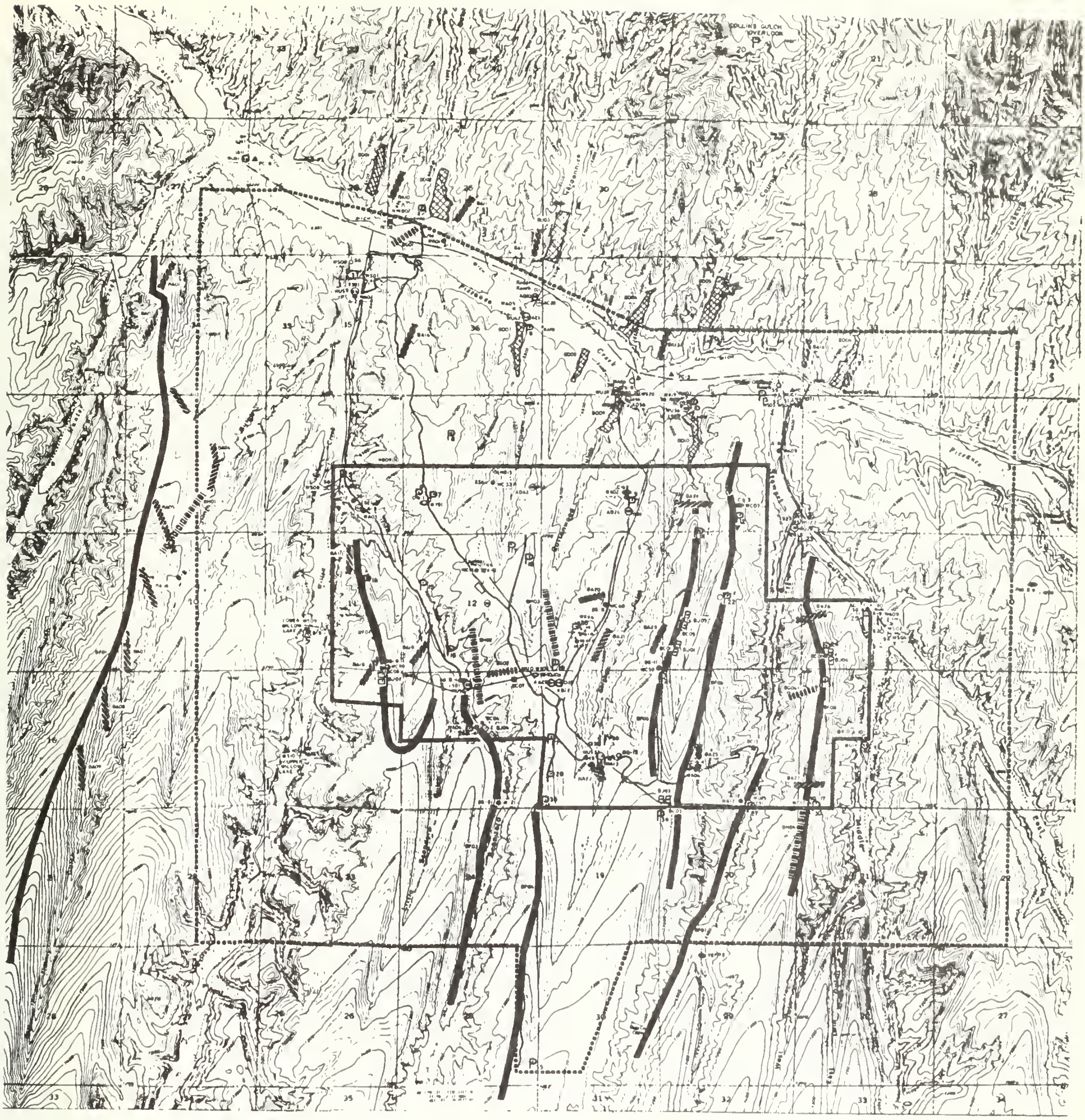

DEVELOPMENT
MONITORING
ACTIVITIES

REVISION 1
MAR 8, 1979

APPENDIX H

1978 C-b Annual Report, Volume 2A

1978 C-b ANNUAL REPORT

APPENDIX 2A

VOLUME 2 SUPPORTING DATA

April 20, 1979

Submitted by:

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to:

Mr. Peter A. Rutledge
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FOREWORD

The 1978 C-b ANNUAL REPORT is submitted to fulfill the requirements of the Oil Shale Lease as stated in Section 16(b) of the Lease, Section 1.(C)(4) of the Lease Environmental Stipulations, and Conditions of Approval (No. 3) of the Detailed Development Plan. This report consists of the following volumes:

Volume 1 - Summary of Development Activities, Costs and Environmental Monitoring
Volume 2 - Environmental Analysis
Appendix 2A - Volume 2 Supporting Data
Appendix 2B - Volume 2 Time Series Plots

LIST OF APPENDIX 2A FIGURES REFERENCED IN TEXT

LIST OF APPENDIX 2A TABLES REFERENCED IN TEXT

LIST OF APPENDIX 2A TABLES REFERENCED IN TEXT

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LIST OF APPENDIX 2A TABLES REFERENCED IN TEXT

LIST OF SUPPORTING APPENDICES

USERS GUIDE TO APPENDIX 2A

Appendix 2A contains supporting data for the 1978 C-b Annual Report, Volume 2, Environmental Analysis. These data appear in the forms of figures and tables and within the context of documentation for special analyses performed during the period of this report.

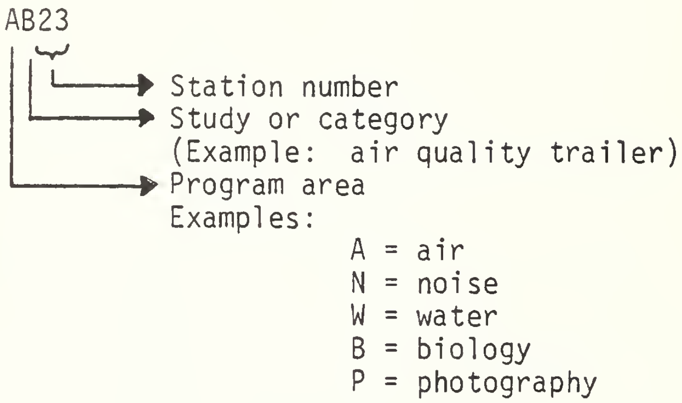
Both a list of figures and a list of tables, which are referenced in Volume 2 as belonging in Appendix 2A, appear immediately following the cover page of this appendix. A list of smaller, supporting appendices can be found following the list of tables; figures and tables not specifically referenced in Volume 2, but found in Appendix 2A, are listed on the title page of each supporting appendix.

Numbers assigned to supporting appendices, figures, and tables serve as a cross reference to section designations of Volume 2. The second- and third-level numbers correspond to the same second- and third-level section numbers in Volume 2 (e.g., Table A5.2.1A contains supporting data for section 5.2.1 of Volume 2, while Appendix A6.3.2B contains supporting data for section 6.3.2 of Volume 2). The header and trailer letter designations on all supporting appendices, figures, and tables refer to the physical location of the document in Appendix 2A and to a special study type (within the third-level designation), respectively. All supporting appendices, figures, and tables appear in numerical order by section number.

APPENDIX A2.2

COMPUTER STATION CODES AND CROSS-REFERENCE

A four-digit computer station code has been designed for identfying stations in the computer data base management system. It consists of two letters followed by two numbers:



This code is presented on Table A2.2-1 for the environmental program. Associated station maps appearing in this report are:

	Figure	Page
WATER	5.2.1-1	26
	5.2.2-1	39
	5.3.1-1	43
	5.3.2-1	48
AIR	6.2.1-1	53
	6.3.1-1	91
NOISE	7.1.1-1	116
BIOLOGY	Jacket	Back Cover

TABLE A2.2-1
COMPUTER STATION CODES

		Sta. Designation	Computer Code
I	Air Quality & Meteorology		
	Met. Tower:	@ Sta 023	AA23
	Trailers:	Sta 020	AB20
		021	AB21
		022	AB22
		023	AB23
		024	AB24
	Acoustic Radar	Sta 020	AC20
		021	AC21
		023	AC23
	MRI and Particulates	Sta 031	AD31
		032	AD32
		033	AD33
		041	AD41
		042	AD42
		043	AD43
		044	AD44
		056	AD56
II	Noise		
	Traffic Noise	Sta II	NA02
		IX	NA09
		XV	NB15
III	Water		
	USGS Stream Gauging Sta.	09306007	WU07
		36	WU36
		39	WU39
		42	WU42
		61	WU61
		50	WU50
		52	WU52
		58	WU58
		33	WU33
		25	WU25
		15	WU15
		08	WU08
		22	WU22
	Springs & Seeps	S-1	WS01
		2	WS02
		3	WS03
		4	WS04
		6	WS06
		7	WS07
		8	WS08
		9	WS09
		10	WS10
		S-A	WS11
	Alluvial Wells	A-1	WA01
		A-2	WA02
		-2A	WA14
		3	WA03
		3A	WA15
		4	WA04

TABLE A2.2-1

		Computer Code
Water Cont'd		
Alluvial Wells Cont'd	5	WA05
	5A	WA16
	6	WA06
	6A	WA17
	7	WA07
	7A	WA18
	8	WA08
	9	WA09
	10	WA10
	11	WA11
	12	WA12
	13	WA13

TABLE A2.2-1

Deep Wells

UPPER AQUIFER

Baseline and Before Recompletions		U1 Level (String 1) After Recompletions		UPC1 Level (String 2) After Recompletions		UPC2 Level (String 3 After Recompletions	
STA.	CODE	STA.	CODE	STA.	CODE	STA.	CODE
CB-2	WX02	CB-2	WC02	CB-2	WD02		
		CB-3 .	WC03			CB-3	WE03
CB-4	WX04	CB-4	WC04			CB-4	WE04
		AT-1B	WC41	AT-1B-3	WD43		
AT-1C-3	WX44						
SG-1-2	WX12	SG-1	WC12	SG-1	WD12		
		SG-1A	WC13	SG-1A-2	WD13		
SG-6-3	WX63	SG-6	WC60	SG-6-3	WD63	SG-6-1	WE61
SG-8-2	WX82						
SG-9-2	WX92	SG-9	WC90			SG-9-2	WE92
SG-10A	WX10	SG-10A	WC10	SG-10A-2	WD10	SG-10A-1	WE10
SG-11-3	WX55	SG-11	WC50	SG-11-3	WD55	SG-11-2	WE54
SG-17-2	WX17	SG-17	WC17	SG-17-3	WD17	SG-17-2	WE17
SG-18A	WX18	SG-18A	WC18	SG-18A-3	WD18	SG-18A-2	WE18
SG-19	WX19	SG-19	WC19				
SG-20	WX20	SG-20	WC20	SG-20-3	WD20	SG-20-2	WE20
SG-21	WX21	SG-21	WC21	SG-21-4	WD21	SG-21-3	WE21
		33X-1	WC33	33X-1-4	WD33	33X-1-3	WE33
		32X-12	WC32	32X12-4	WD32	32X12-3	WE32

TABLE A2.2-1

Deep Wells (cont'd)

LOWER AQUIFER

Baseline and Before Recompletions		LPC3 Level (String 4) After Recompletions		LPC4 Level (String 5) After Recompletions		
STA.	CODE	STA.	CODE	STA.	CODE	
CB-1	WY01					
AT-1	WY44	AT-1A	WG40			
		AT-1B-1	WG42			
AT-1C-1	WY45					
AT-1C-2	WY46					
SG-1-1	WY12	SG-1-1	WG12			
SG-6-1	WY61					
SG-6-2	WY62	SG-6-2	WG62			
SG-8	WY80	SG-8-1	WG81	SG-8-2	WH82	
SG-8R	WY81					
SG-9-1	WY91	SG-9-1	WG91			
SG-10	WY09	SG-10	WG10			
SG-10R	WY10					
SG-11-1	WY51	SG-11-1	WG52			
SG-11-2	WY54					
SG-11-1R	WY52					
SG-17-1	WY18	SG-17-1	WG17			
SG-17-1R	WY17					
		SG-18A-1	WG18			
		SG-20-1	WG20			
		SG-21-2	WG21	SG-21-1	WH21	
		33X-1-2	WG33	ddX-1-1	WH33	
		32X-12-2	WG32	32X-12-1	WH32	

IV Biology

Program	General Location	Computer Code	*Analysis Code
Deer Days Use	Between Hunter Cr. & Jimmy Gulch	BA01	- PJ-CH-C
		BA02	- PJ-CH-C
		BA03	- PJ-CH-C
		BA04	- PJ-CH-C
		BA05	- PJ-CH-C
		BA06	- PJ-CH-C
		BA07	- PJ-CH-C
		BA08	- PJ-CH-C
		BA09	- PJ-CH-C
	North Side, Piceance Creek	BA10	- PJ -D
		BA11	- PJ -D
		BA12	- PJ -D
		BA13	- PJ -C
		BA14	- PJ -C
		BA15	- PJ -C
	South Side, Piceance Creek	BA16	- PJ -D
	On Tract Bet. Willow & Scandard	BA17	- PJ-CH-C
		BA18	- PJ-CH-C
		BA19	- PJ -C
	On Tract bet. Cottonwood & Sorghum	BA20	- PJ-CH-D
		BA21	- PJ-CH-D
		BA22	- PJ -D
	On Tract bet. Sorghum & W. Fork Stewart	BA23	- PJ-CH-D
		BA24	- PJ -D
		BA25	- PJ-CH-C
	On Tract bet. W.& M. Fork Stewart	BA26	- PJ -C
		BA27	- PJ -C
	On Tract bet. Willow & Scandard North End	BA28	- PJ-CH-C
	On Tract bet. Willow & Scandard S.E.	BA29	- PJ-CH-C
	On Tract bet. Cottonwood & Sorghum North	BA30	- PJ-CH-C
	On Tract bet. Cottonwood & Sorghum South	BA31	- PJ-CH-C

*ANALYSIS CODES:

PJ-CH-C	- Pinon Juniper, Chained, Control Station	(12)
PJ -C	- Pinon Juniper, Control Station	(6)
PJ-CH-D	- Pinon Juniper, Chained, Development Station	(3)
PJ -D	- Pinon Juniper, Development Station	(6)

TABLE A2.2-1

Biology Cont'd

Program	General Location	Computer Code
Deer Mortality	North Side of Piceance Creek	BD01
		BD02
		BD03
		BD04
		BD05
		BD06
	South Side of Piceance Creek	BD07
		BD08
		BD09
		BD10
Deer Age Class	General Area of Tract	BE01
Coyotte Abundance	8 Transects for Total of 30 miles	BF01
	15 mi seg. near Hunter (control)	BF02 thru BF08
	15 mi seg. on & South of Tract (development)	
Lagomorph Abundance	Identical Locations to deer use days	BA01 to BA27
Small Mammals	Piceance Creek (Development)	BG01
	On-Tract-west (Development)	BG02
	Piceance Creek (Control)	BG03
	On Tract-east (Control)	BG04
Avifauna		
Songbirds and Gamebirds	N.W. of Tract-near Jimmy PJ-CH-C	BH01
	On Tract-Scandard PJ -D	BH02
	On Tract-Cottonwood PJ-CH-D	BH03
	S. of Tract-bet. W&N Fork Stewart PJ -C	BH04
Raptors	The entire tract and surrounding study areas.	BI01
Aquatic Ecology		
Benthos	USGS 90306007 (Control)	WU07
	USGS 58 (Development)	WU58
	USGS 61 (Development)	WU61
Periphyton	Piceance Creek Upstream (Control)	WP01
		WP02
	Piceance Creek Downstream (Development)	WP03
Water Quality	USGS 09306061 (Development)	WU61
Vegetation		
Community Structure		
	Chained pinyon juniper (1978)(Dev)	BJ01
	Chained pinyon juniper (1978)(Cont)	BJ02
	Upland sagebrush (1980)(Cont)	BJ03
	Bottomland sagebrush (1980)(Cont)	BJ04
	Pinyon juniper woodland (1979)(Dev)	BJ05
	Pinyon juniper woodland (1979)(Cont)	BJ06
Herb Productivity and Utilization	Identical locations to community structure	BJ01 thru BJ06
	Plus	
	60 range cages in random locations	BK01 thru BK60
	20 cages on south facing PJ for baseline	BK61 thru BK80
	5 cages for fertilization assessment	BK81 thru BK85
Shrub Productivity and Utilization	Same stations as Deer Use Days Study	BA01 thru BA27
General Condition	By aircraft over entire Tract area	Not in computer

TABLE A2.2-1

Biology (Cont'd)

Programs: Deer Distribution & Migration and Road Kills

Mile Marker	Location	Computer Code	
		North of Piceance Creek	South(Meadows) of Piceance Creek
41	White River City	BN41	BM41
40	Piceance Bridge	BN40	BM40
39	Lower Canyon	BN39	BM39
38	Piceance Canyon	BN38	BM38
37	Yellow Creek	BN37	BM37
36	Stinking Springs	BN36	BM36
35	Old Bridge	BN35	BM35
34	Little Hills Turnoff	BN34	BM34
33	Old Corrals & Buildings	BN33	BM33
32	Burk Ranch	BN32	BM32
31	2 Ranch	BN31	BM31
30		BN30	BM30
29		BN29	BM29
28	Bureau of Mines	BN28	BM28
27	Ryan Gulch	BN27	BM27
26	Pump Station	BN26	BM26
25		BN25	BM25
24	Rock School	BN24	BM24
23	AQ 021	BN23	BM23
22	Pat Johnson's Ranch	BN22	BM22
21	Hunter Creek	BN21	BM21
20	PL Gate	BN20	BM20
19	AQ 020	BN19	BM19
18	Sorghum, Cottonwood	BN18	BM18
17	Stewart Gulch Rd.	BN17	BM17
16	A Q Trailer 022	BN16	BM16
15	Oldland's Ranch	BN15	BM15
14	Oldland's Ranch	BN14	BM14
13	Pond and Cabin	BN13	BM13
12	Sprague Gulch	BN12	BM12
11	Cascade Gulch	BN11	BM11
10	13 Mile Gulch	BN10	BM10
9	14 Mile Gulch	BN09	BM09
8	Schutte Gulch	BN08	BM08
7	Robinson's Ranch	BN07	BM07
6		BN06	BM06
5	2 Old Cabins (35 MPH Curve)	BN05	BM05
4	McCarthy Gulch	BN04	BM04
3	Cow Creek	BN03	BM03
2	Mahogany Outcropping	BN02	BM02
1	Woodward Ranch	BN01	BM01
0	Rio Blanco Store	BN00	BM00

Biology (Cont'd)

Program	General Location	Computer Code
Micro Climate	MC Sta. 1	BC01
	2	BC02
	3	BC03
	4	BC04
	5	BC05
	6	BC06
	7	BC07
	8	BC08
	9	BC09
	13	BC13

APPENDIX A5.2.1

This Appendix consists of four parts:

A5.2.1A - Summary Tables for Univariate Time Series Analyses

A5.2.1B - Data for USGS Major Gauging Stations

A5.2.1C - T-TEST Procedure Results for USGS Gauging Stations

A5.2.1D - Univariate Time Series Analysis UCS FORTELL Box-Jenkins Package

APPENDIX A5.2.1A

Summary Tables for Univariate Time Series Analyses

List of Tables Appearing in Appendix A5.2.1A

Table A5.2.1A-1

UNIVARIATE TIME SERIES ANALYSES

MEAN MONTHLY FLOW (cfs)

MAJOR USGS STATIONS

USGS Sta #	MODEL PARAMETERS	SERIES MEAN	SERIES S. D.	MEAN OF RESIDUALS	S. D. OF RESIDUALS	CHI SQUARE TEST (95%)	TREND
007	μ = 10.176 ϕ_1 = 0.53076	9.9997	8.0671	0.36053E-03	0.68633E+01	NOISE	N
022	μ = 1.632 ϕ_1 = 0.62038	1.6733	0.62628	-0.32148E-05	0.49960	NOISE	N
058	μ = 1.7194 ϕ_1 = 0.65157	1.7002	0.97969	-0.10046E-02	0.74408	NOISE	N
061	μ = 14.239 ϕ_1 = 0.59035	14.069	7.3146	-0.20778E-02	0.58856E+01	NOISE	N

General Form of Time Series Model for Mean Monthly Flow

$$(1-\phi_1 B^1)\ (Z_t-\mu) = a_t$$

ϕ_a = Autoregressive parameter of order a
θ_b = Moving average parameter of order b

Table A5.2.1A-2

UNIVARIATE TIME SERIES ANALYSES

SO_4 CONCENTRATION (mg/l)

MAJOR USGS STATIONS

USGS Sta #	MODEL PARAMETERS	SERIES MEAN	SERIES S. D.	MEAN OF RESIDUALS	S. D. OF RESIDUALS	CHI SQUARE TEST (95%)	TREND
007	M = 165.85 $\phi_4 =$ 0.25727	165.40	16.436	0.19576E-03	0.16648E+02	NOISE	N
022	M = 367.99 $\phi_1 =$ 0.30307	367.53	17.924	-0.17136E+00	0.17138E+02	NOISE	N
058	M = 337.09 $\phi_1 =$ 0.41802	337.00	20.067	0.19789E-03	0.18447E+02	-	N
061	M = 296.93 $\phi_1 =$ 0.49512	297.22	47.005	-0.89333E-03	0.41248E+02	NOISE	N

General Form of Time Series Model for SO_4 Concentration

Stations 022, 058, 061 $(1-\phi_1 B^1)\ (Z_t-\mu) = a_t$

Station 007 $(1-\phi_4 B^4)\ (Z_t-\mu) = a_t$

ϕ_a = Autoregressive parameter of order a

θ_b = Moving average parameter of order b

Table A 5.2.1A-3

UNIVARIATE TIME SERIES ANALYSES

NA CONCENTRATION (mg/l)

MAJOR USGS STATIONS

USGS Sta #	MODEL PARAMETERS	SERIES MEAN	SERIES S. D.	MEAN OF RESIDUALS	S. D. OF RESIDUALS	CHI SQUARE TEST (95%)	TREND
007	M = 122.95 ϕ_1= 0.163	123.22	19.633	-.17912E-01	0.19441E+02	NOISE	N
022	M = 123.42 ϕ_7= .47099 ϕ_8= 0.012231	124.64	11.017	-.38878E-04	0.47358E+01	NOISE	N
058	M = 118.93 ϕ_1= 0.58705	119.44	8.4474	-.19285E-03	0.65648E+01	-	N
061	M = 146.92 ϕ_1= 0.46995	147.33	22.937	-.14461E-03	0.20202E+02	NOISE	N

General Form of Time Series Model for Na Concentration

Stations 007, 058, 061 $(1-\phi_1 B^1)\ (Z_t-\mu) = a_t$

Station 022 $(1-\phi_7 B^7)\ (1-\phi_8 B^8)\ (Z_t-\mu) = a_t$

ϕ_a = Autoregressive parameter of order a
θ_b = Moving average parameter of order b

APPENDIX A5.2.1B

Data for USGS Major Gauging Stations

PH DATA 10/74 - 5/78

8.5	8.0	8.1	8.7	7.9	8.4	8.5	8.5	8.4	8.3	8.2	8.3	8.2	8.2	8.2
8.3	8.3	8.0	8.3	8.3	8.3	8.2	MD	8.3	MD	8.3	MD	8.3	8.2	MD
8.1	8.2	8.4	8.1	7.9	8.3	8.2								

B DATA 10/74 - 5/78

244	240	187	205	175	215	150	265	200	210	215	215	210	200	180	190	210
130	140	220	MD	MD	220	210	MD	190	MD	200	MD	180	MD	MD	240	MD
250	240	240	190	200	130	150										

FLUORIDE DATA 10/74 - 5/78

1.1	1.0	1.1	1.2	1.2	1.0	0.5	0.7	0.8	0.9	0.9	0.8	1.0	1.1	1.1	1.0	1.0
0.6	0.9	0.1	1.1	MD	1.1	1.1	MD	1.2	MD	1.3	MD	1.1	MD	1.2	1.2	MD
1.0	1.2	1.2	1.2	1.3	0.7	0.6										

AS DATA 10/74 - 5/78

USGS Station WU07 Data Prior to Interpolation

PH DATA 10/74 - 5/78

8.2	8.5	8.5	8.4	8.6	8.5	8.5	8.2	8.1	8.5	8.1	8.3	8.0	8.2	8.3	8.3	8.3	8.3
8.3	8.3	8.3	8.0	7.1	8.3	8.4	8.2	MD	8.2	MD	8.3	MD	8.2	MD	8.2	8.2	MD
8.2	8.3	8.2	8.2	8.1	7.9	8.0	8.3										

B DATA 10/74 - 5/78

100	325	140	120	75	77	85	80	80	70	75	85	145	80	90	80	80	180
80	110	310	MD	MD	MD	80	80	MD	70	MD	80	MD	MD	MD	MD	MD	MD
80	100	90	80	90	80	80	80										

FLUORIDE DATA 10/74 - 5/78

.2	2.0	.8	.2	.3	.2	.2	.2	.2	.2	.3	.2	.2	.3	.2	.3	.2	.2
.2	.3	.2	MD	MD	MD	.3	.3	MD	.3	MD	.5	MD	.3	MD	.2	.3	MD
.3	.3	.3	.3	.3	.2	.2	.3										

AS DATA 10/74 - 5/78

1 2 1 1 2 1 0 .5 0 1 .5 1 1 1 1 1 1 MD MD 0 1 MD MD MD
1 1 MD 2 MD 1 MD MD MD MD MD MD 2 2 1 1 1 1 1 1

USGS Station WU22 Data Prior to Interpolation

PH DATA 10/74 - 5/78

8.4	7.4	8.47	8.71	8.34	8.3	8.56	8.5	8.4	8.5	8.5	8.5	8.7	8.7	
8.9	8.4	8.4	8.4	8.1	8.4	8.3	8.3	8.4	8.1	8.4	MD	MD	MD	MD
8.3	MD	8.4	8.3	8.4	MD	8.4	8.4	8.4	8.3	8.4	8.1	8.1	8.3	

B DATA 10/74 - 5/78

105	MD	MD	MD	MD	MD	120	110	130	100	120	125	120	100		
110	90	100	140	830	2800	130	120	MD	MD	100	100	MD	MD	MD	MD
100	MD	110	MD	MD	120	MD	110	110	110	100	100	130	110		

FLUORIDE DATA 10/74 - 5/78

.4	MD	MD	MD	MD	MD	.3	.3	.4	.4	.4	.4	.4	.5	.4	.3	.4	.4	.4	.4	MD	MD
.3	.4	MD	MD	MD	.5	MD	.5	MD	.4	.4	MD	.4	.4	.4	.6	.4	.4	.4	MD		

AS DATA 10/74 - 5/78

1	MD	MD	MD	MD	MD	3	1	1	1	1	1	1	1	0	MD	0	0	1	1	MD	MD
1	13	MD	MD	MD	1	MD	0	MD	MD	3	MD	2	3	2	1	2	1	1	1		

USGS Station WU58 Data Prior to Interpolation

PH DATA 10/74 - 5/78

8.3	8.3	8.3	8.2	7.7	8.4	8.0	9.2	7.8	8.4	8.3	8.5	7.8	8.2	8.3	8.3	8.3	8.4
8.3	8.3	8.3	8.2	8.1	8.3	8.1	8.3	8.1	8.2	8.3	8.2	8.0	8.1	8.4	8.2	8.3	8.1
8.3	8.1	8.3	8.1	8.1	8.2	7.8	8.5										

B DATA 10/74 - 5/78

220	210	190	175	155	145	155	160	205	215	185	190	190	200	160	140	140	200
390	770	230	240	MD	MD	180	190	180	160	150	150	150	180	200	190	220	200
190	190	190	170	180	140	120	170										

FLUORIDE DATA 10/74 - 5/78

.6	.6	.6	.7	.6	.8	.6	.5	.7	.7	.7	.7	5	.8	.7	.6	.6	.6	.6	.7	.7	.8	MD	MD
.6	.7	.6	.7	.7	.8	.8	.9	.8	.7	.7	.7	7	.7	.7	.7	.7	.6	.5	.7				

AS DATA 10/74 - 5/78

2	3	2	1	3	1	2	2	1	3	3	3	3	1	2	2	1	MD	1	1	4	4	MD	MD
2	3	3	2	0	2	2	2	3	3	1	2	3	6	2	4	2	2	3	2				

USGS Station WU61 Data Prior to Interpolation

```
TIME SERIES ANALYSIS OF MEAN MONTHLY FLOW (STA. 007)                          00000160

LISTING OF OBSERVED SERIES

  1-   8  0.430000E+01 0.854000E+01 0.679000E+01 0.785000E+01 0.772000E+01 0.768000E+01 0.176100E+02 0.463900E+02
  9-  16  0.220900E+02 0.107900E+02 0.147600E+02 0.148000E+02 0.807000E+01 0.101200E+02 0.706000E+01 0.723000E+01
 17-  24  0.101000E+02 0.105600E+02 0.180000E+02 0.103500E+02 0.104100E+02 0.165000E+02 0.127900E+02 0.893000E+01
 25-  32  0.522000E+01 0.786000E+01 0.735000E+01 0.589000E+01 0.572000E+01 0.686000E+01 0.207000E+01 0.413000E+01
 33-  40  0.431000E+01 0.595000E+01 0.270000E+01 0.231000E+01 0.196000E+01 0.361000E+01 0.476000E+01 0.340000E+01
 41-  48  0.308000E+01 0.117200E+02 0.334300E+02 0.250000E+02 0.833000E+01 0.716000E+01 0.894000E+01 0.660000E+01
```

```
TIME SERIES ANALYSIS OF MEAN MONTHLY FLOW (STA. 022)                          00000160

LISTING.OF OBSERVED SERIES

  1-   8  0.184000E+01 0.205000E+01 0.196000E+01 0.209000E+01 0.175000E+01 0.206000E+01 0.232000E+01 0.234000E+01
  9-  16  0.245000E+01 0.246000E+01 0.202000E+01 0.191000E+01 0.182000E+01 0.170000E+01 0.239000E+01 0.168000E+01
 17-  24  0.183000E+01 0.420000E+01 0.248000E+01 0.229000E+01 0.203000E+01 0.152000E+01 0.155000E+01 0.470000E+00
 25-  32  0.147000E+01 0.150000E+01 0.147000E+01 0.158000E+01 0.174000E+01 0.161000E+01 0.157000E+01 0.121000E+01
 33-  40  0.102000E+01 0.140000E+01 0.660000E+00 0.108000E+01 0.120000E+01 0.141000E+01 0.155000E+01 0.163000E+01
 41-  48  0.157000E+01 0.143000E+01 0.142000E+01 0.130000E+01 0.107000E+01 0.490000E+00 0.630000E+00 0.780000E+00
```

```
TIME SERIES ANALYSIS OF MEAN MONTHLY FLOW (STA. 058)                          00000160

LISTING OF OBSERVED SERIES

  1-   8  0.670000E+00 0.180000E+01 0.235000E+01 0.241000E+01 0.206000E+01 0.336000E+01 0.294000E+01 0.730000E+00
  9-  16  0.136000E+01 0.217000E+01 0.209000E+01 0.101000E+01 0.324000E+01 0.311000E+01 0.317000E+01 0.272000E+01
 17-  24  0.435000E+01 0.326000E+01 0.314000E+01 0.139000E+01 0.800000E+00 0.530000E+00 0.110000E+01 0.243000E+01
 25-  32  0.257000E+01 0.189000E+01 0.273000E+01 0.167000E+01 0.114000E+01 0.156000E+01 0.710000E+00 0.500000E+00
 33-  40  0.800000E+00 0.109000E+01 0.102000E+01 0.950000E+00 0.124000E+01 0.133000E+01 0.145000E+01 0.117000E+01
 41-  48  0.158000E+01 0.151000E+01 0.136000E+01 0.420000E+00 0.670000E+00 0.650000E+00 0.380000E+00 0.530000E+00
```

```
TIME SERIES ANALYSIS OF MEAN MONTHLY FLOW (STA. 061)                          00000160

LISTING OF OBSERVED SERIES

  1-   8  0.553000E+01 0.165000E+02 0.176000E+02 0.165000E+02 0.164000E+02 0.205000E+02 0.234000E+02 0.367000E+02
  9-  16  0.250000E+02 0.134000E+02 0.168000E+02 0.180000E+02 0.112300E+02 0.250000E+02 0.224800E+02 0.172900E+02
 17-  24  0.210300E+02 0.218100E+02 0.280900E+02 0.793000E+01 0.506000E+01 0.717000E+01 0.135300E+02 0.197000E+02
 25-  32  0.534000E+01 0.102300E+02 0.164200E+02 0.139700E+02 0.129300E+02 0.126900E+02 0.467000E+01 0.614000E+01
 33-  40  0.584000E+01 0.710000E+01 0.842000E+01 0.107700E+02 0.335000E+01 0.520000E+01 0.101000E+02 0.109100E+02
 41-  48  0.106700E+02 0.146300E+02 0.257700E+02 0.208100E+02 0.931000E+01 0.800000E+01 0.645000E+01 0.497000E+01
```

Flow Data - (Oct. 1974 - Sept. 1978)

```
TIME SERIES ANALYSIS OF SO4 CONCENTRATION (STA. 007)                              00000160
LISTING OF OBSFRVED SERIES

  1-   8  0.170000E+03 0.160000E+03 0.155000E+03 0.160000E+03 0.170000E+03 0.140000E+03 0.175000E+03 0.140000E+03
  9-  16  0.145000E+03 0.170000E+03 0.170000E+03 0.170000E+03 0.175000E+03 0.160000E+03 0.150000E+03 0.150000E+03
 17-  24  0.150000E+03 0.150000E+03 0.140000E+03 0.140000E+03 0.190000E+03 0.190000E+03 0.170000E+03 0.170000E+03
 25-  32  0.170000E+03 0.180000E+03 0.170000E+03 0.160000E+03 0.160000E+03 0.160000E+03 0.160000E+03 0.160000E+03
 33-  40  0.165000E+03 0.170000E+03 0.180000E+03 0.180000E+03 0.190000E+03 0.180000E+03 0.160000E+03 0.170000E+03
 41-  45  0.210000E+03 0.150000E+03 0.150000E+03 0.140000E+03 0.210000E+03
```

```
TIME SERIES ANALYSIS OF SO4 CONCENTRATION (STA. 022)                              00000160
LISTING OF OBSERVED SERIES

  1-   8  0.360000E+03 0.340000E+03 0.354000E+03 0.380000E+03 0.375000E+03 0.370000E+03 0.365000E+03 0.370000E+03
  9-  16  0.375000E+03 0.435000E+03 0.395000E+03 0.385000E+03 0.360000E+03 0.370000E+03 0.370000E+03 0.360000E+03
 17-  24  0.370000E+03 0.340000E+03 0.360000E+03 0.360000E+03 0.380000E+03 0.400000E+03 0.375000E+03 0.330000E+03
 25-  32  0.390000E+03 0.360000E+03 0.360000E+03 0.360000E+03 0.360000E+03 0.360000E+03 0.370000E+03 0.380000E+03
 33-  40  0.380000E+03 0.380000E+03 0.370000E+03 0.370000E+03 0.360000E+03 0.380000E+03 0.360000E+03 0.370000E+03
 41-  45  0.350000E+03 0.330000E+03 0.350000E+03 0.350000E+03 0.370000E+03
```

```
TIME SERIES ANALYSIS OF SO4 CONCENTRATION (STA. 058)                              00000160
LISTING OF OBSFRVED SERIES

  1-   8  0.340000E+03 0.325000E+03 0.325000E+03 0.325000E+03 0.325000E+03 0.325000E+03 0.310000E+03 0.345000E+0
  9-  16  0.375000E+03 0.345000E+03 0.360000E+03 0.365000E+03 0.340000E+03 0.320000E+03 0.350000E+03 0.310000E+0
 17-  24  0.320000E+03 0.290000E+03 0.330000E+03 0.330000E+03 0.390000E+03 0.380000E+03 0.360000E+03 0.310000E+0
 25-  32  0.350000E+03 0.320000E+03 0.320000E+03 0.320000E+03 0.320000E+03 0.320000E+03 0.340000E+03 0.360000E+0
 33-  40  0.350000E+03 0.350000E+03 0.350000E+03 0.350000E+03 0.340000E+03 0.320000E+03 0.330000E+03 0.330000E+0
 41-  45  0.320000E+03 0.330000E+03 0.350000E+03 0.350000E+03 0.350000E+03
```

```
TIME SERIES ANALYSIS OF SO4 CONCENTRATION (STA. 061)                              00000160
LISTING OF OBSERVED SERIES

  1-   8  0.315000E+03 0.295000E+03 0.285000E+03 0.295000E+03 0.315000E+03 0.255000E+03 0.250000E+03 0.210000E+03
  9-  16  0.245000E+03 0.315000E+03 0.250000E+03 0.275000E+03 0.350000E+03 0.250000E+03 0.280000E+03 0.280000E+03
 17-  24  0.290000E+03 0.270000E+03 0.190000E+03 0.290000E+03 0.380000E+03 0.390000E+03 0.260000E+03 0.280000E+03
 25-  32  0.310000E+03 0.330000E+03 0.290000E+03 0.300000E+03 0.280000E+03 0.320000E+03 0.350000E+03 0.290000E+03
 33-  40  0.330000E+03 0.350000E+03 0.365000E+03 0.365000E+03 0.380000E+03 0.360000E+03 0.330000E+03 0.300000E+03
 41-  45  0.290000E+03 0.260000E+03 0.200000E+03 0.220000E+03 0.320000E+03
```

SO_4 Concentration Data (Oct. 1974 - June 1978)

```
          TIME SERIES ANALYSIS OF NA CONCENTRATION (STA. 007)                                     00000160
          LISTING OF OBSERVED SERIES

  1-   8  0.140000E+03 0.135000E+03 0.125000E+03 0.130000E+03 0.130000E+03 0.115000E+03 0.120000E+03 0.950000E+02
  9-  16  0.110000E+03 0.135000E+03 0.125000E+03 0.120000E+03 0.130000E+03 0.120000E+03 0.120000E+03 0.110000E+03
 17-  24  0.110000E+03 0.110000E+03 0.850000E+02 0.110000E+03 0.140000E+03 0.140000E+03 0.120000E+03 0.470000E+02
 25-  32  0.150000E+03 0.140000E+03 0.130000E+03 0.120000E+03 0.120000E+03 0.120000E+03 0.125000E+03 0.130000E+03
 33-  40  0.130000E+03 0.130000E+03 0.140000E+03 0.140000E+03 0.150000E+03 0.140000E+03 0.130000E+03 0.130000E+03
 41-  45  0.140000E+03 0.120900E+03 0.800000E+02 0.980000E+02 0.160000E+03


          TIME SERIES ANALYSIS OF NA CONCENTRATION (STA. 022)                                     00000160
          LISTING OF OBSERVED SERIES

  1-   8  0.122000E+03 0.190000E+03 0.122000E+03 0.120000E+03 0.120000E+03 0.120000E+03 0.120000E+03 0.125000E+03
  9-  16  0.120000E+03 0.135000E+03 0.130000E+03 0.125000E+03 0.125000E+03 0.120000E+03 0.120000E+03 0.120000E+03
 17-  24  0.120000E+03 0.120000E+03 0.120000E+03 0.130000E+03 0.130000E+03 0.120000E+03 0.120000E+03 0.120000E+03
 25-  32  0.120000E+03 0.120000E+03 0.120000E+03 0.120000E+03 0.120000E+03 0.120000E+03 0.125000E+03 0.130000E+03
 33-  40  0.130000E+03 0.130000E+03 0.130000E+03 0.130000E+03 0.130000E+03 0.120000E+03 0.120000E+03 0.130000E+03
 41-  45  0.110000E+03 0.120000E+03 0.120000E+03 0.120000E+03 0.130000E+03


          TIME SERIES ANALYSIS OF NA CONCENTRATION (STA. 058)                                     00000160
          LISTING OF OBSERVED SERIES

  1-   8  0.135000E+03 0.125000E+03 0.125000E+03 0.125000E+03 0.125000E+03 0.125000E+03 0.110000E+03 0.120000E+03
  9-  16  0.130000E+03 0.125000E+03 0.130000E+03 0.135000E+03 0.120000E+03 0.110000E+03 0.120000E+03 0.110000E+03
 17-  24  0.110000E+03 0.110000E+03 0.110000E+03 0.110000E+03 0.130000E+03 0.130000E+03 0.130000E+03 0.110000E+03
 25-  32  0.110000E+03 0.110000E+03 0.110000E+03 0.110000E+03 0.110000E+03 0.110000E+03 0.120000E+03 0.130000E+03
 33-  40  0.125000E+03 0.125000E+03 0.125000E+03 0.125000E+03 0.120000E+03 0.110000E+03 0.110000E+03 0.110000E+03
 41-  45  0.110000E+03 0.120000E+03 0.120000E+03 0.125000E+03 0.130000E+03


          TIME SERIES ANALYSIS OF NA CONCENTRATION (STA. 061)                                     00000165
          LISTING OF OBSERVED SERIES

  1-   8  0.177000E+03 0.160000E+03 0.140000E+03 0.140000E+03 0.140000E+03 0.130000E+03 0.130000E+03 0.115000E+03
  9-  16  0.145000E+03 0.170000E+03 0.145000E+03 0.140000E+03 0.160000E+03 0.120000E+03 0.140000E+03 0.120000E+03
 17-  24  0.120000E+03 0.120000E+03 0.970000E+02 0.170000E+03 0.190000E+03 0.150000E+03 0.150000E+03 0.140000E+03
 25-  32  0.150000E+03 0.160000E+03 0.140000E+03 0.140000E+03 0.140000E+03 0.140000E+03 0.180000E+03 0.160000E+03
 33-  40  0.170000E+03 0.170000E+03 0.170000E+03 0.170000E+03 0.170000E+03 0.160000E+03 0.150000E+03 0.130000E+03
 41-  45  0.140000E+03 0.130000E+03 0.910000E+02 0.130000E+03 0.190000E+03
```

23
954

Na Concentration Data (Oct. 1974 - June 1978)

APPENDIX A5.2.1C

T-TEST Procedure Results
for
USGS Stations 6007, 6022, 6058, 6061

```
                                   S T A T I S T I C A L   A N A L Y S I S   S Y S T E M        16:10 MONDAY, MARCH 5, 1979    1
                                                         TTEST PROCEDURE

VARIABLE: PH

LOC        N            MEAN        STD. DEV       STD ERROR         MINIMUM          MAXIMUM    VARIANCES          T        DF   PROB > |T|

6058      27      8.35185185      0.18886375      0.03634685      8.00000000       8.90000000    UNEQUAL       2.0054      55.9       0.0498 *
6061      31      8.24677419      0.21013309      0.03774102      7.70000000       8.70000000    EQUAL         1.9905      56.0       0.0514

FOR HO: VARIANCES ARE EQUAL, F'=     1.24 WITH 30 AND 26 DF      PROB > F'= 0.5842
-----------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: B

LOC        N            MEAN        STD DEV        STD ERROR         MINIMUM          MAXIMUM    VARIANCES          T        DF   PROB > |T|

6058      24    136.66666667    148.31419841     30.27450898     80.00000000     830.00000000    UNEQUAL      -1.7964      43.3       0.0794 *
6061      30    203.33333333    117.57120611     21.46546723    120.00000000     770.00000000    EQUAL        -1.8434      52.0       0.0710

FOR HO: VARIANCES ARE EQUAL, F'=     1.59 WITH 23 AND 29 DF      PROB > F'= 0.2357
-----------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: F

LOC        N            MEAN        STD DEV        STD ERROR         MINIMUM          MAXIMUM    VARIANCES          T        DF   PROB > |T|

6058      26      0.42307692      0.07103629      0.01393136      0.30000000       0.60000000    UNEQUAL     -12.4183      55.7       0.0001 *
6061      32      0.69375000      0.09482582      0.01676299      0.50000000       0.90000000    EQUAL       -12.0562      56.0       0.0001

FOR HO: VARIANCES ARE EQUAL, F'=     1.78 WITH 31 AND 25 DF      PROB > F'= 0.1423
-----------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: AS

LOC        N            MEAN        STD DEV        STD ERROR         MINIMUM          MAXIMUM    VARIANCES          T        DF   PROB > |T|

6058      25      1.64000000      2.49799920      0.49959984               0      13.00000000    UNEQUAL      -1.4315      32.9       0.1617
6061      31      2.41935484      1.20482899      0.21639368               0       6.00000000    EQUAL        -1.5324      54.0       0.1313

FOR HO: VARIANCES ARE EQUAL, F'=     4.30 WITH 24 AND 30 DF      PROB > F'= 0.0002
```

```
                              S T A T I S T I C A L   A N A L Y S I S   S Y S T E M        14:16 MONDAY, MARCH 5, 1979    1
                                                   TTEST PROCEDURE

VARIABLE: MOLY

LOC        N            MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM   VARIANCES          T       DF   PROB > |T|

6058       9      6.77777778      6.45712354      2.15237451      2.00000000     20.00000000   UNEQUAL      -0.7044     17.6       0.4904
6061      13      8.76923077      6.61001571      1.83328851      2.00000000     20.00000000   EQUAL        -0.7012     20.0       0.4912

FOR H0: VARIANCES ARE EQUAL, F'=     1.05 WITH 12 AND 8 DF      PROB > F'= 0.9785
------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: SO4

LOC        N            MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM   VARIANCES          T       DF   PROB > |T|

6058      27    334.81481481     23.59438825      4.54074214    290.00000000    390.00000000   UNEQUAL       3.1772     48.1       0.0026
6061      33    304.24242424     48.73591483      8.48383381    190.00000000    390.00000000   EQUAL         2.9828     58.0       0.0042

FOR H0: VARIANCES ARE EQUAL, F'=     4.27 WITH 32 AND 26 DF      PROB > F'= 0.0003
------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: NA

LOC        N            MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM   VARIANCES          T       DF   PROB > |T|

6058      27    116.66666667      8.32050294      1.60128154    110.00000000    130.00000000   UNEQUAL      -6.7879     40.5       0.0001
6061      33    147.81818182     24.70634350      4.30082236     91.00000000    190.00000000   EQUAL        -6.2594     58.0       0.0001

FOR H0: VARIANCES ARE EQUAL, F'=     8.82 WITH 32 AND 26 DF      PROB > F'= 0.0001
------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: NH3

LOC        N            MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM   VARIANCES          T       DF   PROB > |T|

6058      25      0.03160000      0.02882129      0.00576426               0      0.09000000   UNEQUAL      -1.7123     51.3       0.0929
6061      33      0.05030303      0.05329663      0.00927775               0      0.22000000   EQUAL        -1.5856     56.0       0.1185

FOR H0: VARIANCES ARE EQUAL, F'=     3.42 WITH 32 AND 24 DF      PROB > F'= 0.0027
------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: SPECCOND

LOC        N            MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM   VARIANCES          T       DF   PROB > |T|

6058      27   1251.66666667     78.36060627     15.08050571   1050.00000000   1400.00000000   UNEQUAL      -1.6806     48.3       0.0993
6061      33   1305.00000000    160.39989090     27.92203702    875.00000000   1550.00000000   EQUAL        -1.5787     58.0       0.1198

FOR H0: VARIANCES ARE EQUAL, F'=     4.19 WITH 32 AND 26 DF      PROB > F'= 0.0004
```

```
                                    S T A T I S T I C A L   A N A L Y S I S   S Y S T E M        14:16 MONDAY, MARCH 5, 1979    2
                                                   TTEST PROCEDURE
VARIABLE: TDS
LOC        N             MEAN          STD DEV       STD ERROR         MINIMUM          MAXIMUM    VARIANCES        T         DF  PROB > |T|
6058      25     883.88000000      39.18579675      7.83715935    792.00000000     945.00000000    UNEQUAL     -1.0259       40.2      0.3111
6061      32     905.68750000     111.78159509     19.76038097    584.00000000    1080.00000000    EQUAL       -0.9303       55.0      0.3563
FOR H0: VARIANCES ARE EQUAL, F'=    8.14 WITH 31 AND 24 DF     PROB > F'= 0.0001
```

```
                                   S T A T I S T I C A L   A N A L Y S I S   S Y S T E M    7:31 TUESDAY, FEBRUARY 27, 1979    1
                                                     TTEST PROCEDURE

VARIABLE: PH

LOC          N           MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM    VARIANCES         T        DF   PROB > |T|

6022        27     8.20925926     0.18607124     0.03580943     7.80000000     8.60000000    UNEQUAL     -0.7211      56.0      0.4739
6061        31     8.24677419     0.21013309     0.03774102     7.70000000     8.70000000    EQUAL       -0.7150      56.0      0.4776

FOR H0: VARIANCES ARE EQUAL, F'=    1.28 WITH 30 AND 26 DF     PROB > F'= 0.5323
--------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: B

LOC          N           MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM    VARIANCES         T        DF   PROB > |T|

6022        22    89.54545455    26.09091663     5.56260212    70.00000000   200.00000000    UNEQUAL     -5.1315      32.8      0.0001 *
6061        30   203.33333333   117.57120611    21.46546723   120.00000000   770.00000000    EQUAL       -4.4488      50.0      0.0001

FOR H0: VARIANCES ARE EQUAL, F'=   20.31 WITH 29 AND 21 DF     PROB > F'= 0.0001
--------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: F

LOC          N           MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM    VARIANCES         T        DF   PROB > |T|

6022        27     0.27407407     0.07121253     0.01370486     0.20000000     0.50000000    UNEQUAL    -18.3906      55.4      0.0001 *
6061        32     0.68750000     0.10080323     0.01781966     0.50000000     0.90000000    EQUAL      -17.8683      57.0      0.0001

FOR H0: VARIANCES ARE EQUAL, F'=    2.00 WITH 31 AND 26 DF     PROB > F'= 0.0742
--------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: AS

LOC          N           MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM    VARIANCES         T        DF   PROB > |T|

6022        22     1.13636364     0.46756253     0.09968467              0     2.00000000    UNEQUAL     -5.5137      41.4      0.0001 *
6061        31     2.45161290     1.20661260     0.21671402              0     6.00000000    EQUAL       -4.8497      51.0      0.0001

FOR H0: VARIANCES ARE EQUAL, F'=    6.66 WITH 30 AND 21 DF     PROB > F'= 0.0001
```

```
                              S T A T I S T I C A L   A N A L Y S I S   S Y S T E M        14:11 MONDAY, MARCH 5, 1979
                                                         TTEST PROCEDURE

VARIABLE: MOLY

LOC          N            MEAN          STD DEV        STD ERROR         MINIMUM           MAXIMUM     VARIANCES          T          DF    PROB > |T|

6022         5      4.80000000       5.80517011       2.59615100      1.00000000       15.00000000     UNEQUAL       -1.2489         8.3        0.2459
6061        13      8.76923077       6.61001571       1.83328851      2.00000000       20.00000000     EQUAL         -1.1752        16.0        0.2571

FOR H0: VARIANCES ARE EQUAL, F'=     1.30 WITH 12 AND 4 DF      PROB > F'= 0.8714
-----------------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: SO4

LOC          N            MEAN          STD DEV        STD ERROR         MINIMUM           MAXIMUM     VARIANCES          T          DF    PROB > |T|

6022        28    363.21428571      19.25531604       3.63891269    320.00000000      400.00000000     UNEQUAL        6.3882        43.1        0.0001
6061        33    304.24242424      48.73591483       8.48383381    190.00000000      390.00000000     EQUAL          6.0110        59.0        0.0001

FOR H0: VARIANCES ARE EQUAL, F'=     6.41 WITH 32 AND 27 DF      PROB > F'= 0.0001
-----------------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: NA

LOC          N            MEAN          STD DEV        STD ERROR         MINIMUM           MAXIMUM     VARIANCES          T          DF    PROB > |T|

6022        28    119.42857143      19.44303850       3.67438890     24.00000000      130.00000000     UNEQUAL       -5.0188        58.7        0.0001
6061        33    147.81818182      24.70634350       4.30082236     91.00000000      190.00000000     EQUAL         -4.9214        59.0        0.0001

FOR H0: VARIANCES ARE EQUAL, F'=     1.61 WITH 32 AND 27 DF      PROB > F'= 0.2074
-----------------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: NH3

LOC          N            MEAN          STD DEV        STD ERROR         MINIMUM           MAXIMUM     VARIANCES          T          DF    PROB > |T|

6022        24      0.02708333       0.02710353       0.00553249               0        0.10000000     UNEQUAL       -2.1496        50.0        0.0365
6061        33      0.05030303       0.05329663       0.00927775               0        0.22000000     EQUAL         -1.9551        55.0        0.0557

FOR H0: VARIANCES ARE EQUAL, F'=     3.87 WITH 32 AND 23 DF      PROB > F'= 0.0013
-----------------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: SPECCOND

LOC          N            MEAN          STD DEV        STD ERROR         MINIMUM           MAXIMUM     VARIANCES          T          DF    PROB > |T|

6022        28   1313.21428571      44.89110870       8.48362212   1200.00000000     1380.00000000     UNEQUAL        0.2815        37.8        0.7799
6061        33   1305.00000000     160.39989090      27.92203702    875.00000000     1550.00000000     EQUAL          0.2621        59.0        0.7941

FOR H0: VARIANCES ARE EQUAL, F'=    12.77 WITH 32 AND 27 DF      PROB > F'= 0.0001
```

```
                                     S T A T I S T I C A L   A N A L Y S I S   S Y S T E M        14:11 MONDAY, MARCH 5, 1979    2
                                                          TTEST PROCEDURE

VARIABLE: TDS

LOC         N           MEAN          STD DEV        STD ERROR          MINIMUM          MAXIMUM   VARIANCES          T        DF  PROB > |T|

6022       28   918.60714286      48.10200526       9.09042453     703.00000000     968.00000000   UNEQUAL       0.5940      43.3      0.5556
6061       32   905.68750000     111.78159509      19.76038097     584.00000000    1080.00000000   EQUAL         0.5669      58.0      0.5730

FOR H0: VARIANCES ARE EQUAL, F'=     5.40 WITH 31 AND 27 DF      PROB > F'= 0.0001
```

```
                                    S T A T I S T I C A L   A N A L Y S I S   S Y S T E M    7:30 TUESDAY, FEBRUARY 27, 1979    1
                                                        TTEST PROCEDURE

VARIABLE: PH

LOC        N           MEAN        STD. DEV       STD ERROR        MINIMUM          MAXIMUM    VARIANCES         T        DF  PROB > |T|

6007      28     8.26964286      0.16851161      0.03184570     7.90000000       8.70000000    UNEQUAL      0.4631      56.2      0.6451
6061      31     8.24677419      0.21013309      0.03774102     7.70000000       8.70000000    EQUAL        0.4579      57.0      0.6487

FOR H0: VARIANCES ARE EQUAL, F'=     1.55 WITH 30 AND 27 DF      PROB > F'= 0.2498
-----------------------------------------------------------------------------------------------------------------------------------

VARIABLE: B

LOC        N           MEAN         STD DEV       STD ERROR        MINIMUM          MAXIMUM    VARIANCES         T        DF  PROB > |T|

6007      23   199.56521739     35.86315669      7.47798510   130.00000000     250.00000000    UNEQUAL     -0.1658      35.8      0.8693
6061      30   203.33333333    117.57120611     21.46546723   120.00000000     770.00000000    EQUAL       -0.1482      51.0      0.8828
FOR H0: VARIANCES ARE EQUAL, F'=    10.75 WITH 29 AND 22 DF      PROB > F'= 0.0001
-----------------------------------------------------------------------------------------------------------------------------------

VARIABLE: F

LOC        N           MEAN         STD DEV       STD ERROR        MINIMUM          MAXIMUM    VARIANCES         T        DF  PROB > |T|

6007      28     1.02142857      0.20249763      0.03826846     0.60000000       1.30000000    UNEQUAL      7.9104      38.4      0.0001 *
6061      32     0.68750000      0.10080323      0.01781966     0.50000000       0.90000000    EQUAL        8.2409      58.0      0.0001

FOR H0: VARIANCES ARE EQUAL, F'=     4.04 WITH 27 AND 31 DF      PROB > F'= 0.0003
-----------------------------------------------------------------------------------------------------------------------------------

VARIABLE: AS

LOC        N           MEAN         STD DEV       STD ERROR        MINIMUM          MAXIMUM    VARIANCES         T        DF  PROB > |T|

6007      24     2.62500000      0.76966961      0.15710815     1.00000000       4.00000000    UNEQUAL      0.6478      51.3      0.5200
6061      31     2.45161290      1.20661260      0.21671402     0.00000000       6.00000000    EQUAL        0.6133      53.0      0.5423

FOR H0: VARIANCES ARE EQUAL, F'=     2.46 WITH 30 AND 23 DF      PROB > F'= 0.0294
```

```
                          S T A T I S T I C A L   A N A L Y S I S   S Y S T E M       14:04 MONDAY, MARCH 5, 1979    1
                                                   TTEST PROCEDURE

VARIABLE: MOLY

LOC        N             MEAN         STD.DEV       STD ERROR        MINIMUM          MAXIMUM    VARIANCES         T       DF   PROB > |T|

6007       9       7.22222222      5.01940678      1.67313559     4.00000000      20.00000000    UNEQUAL     -0.6233     19.8       0.5402
6061      13       8.76923077      6.61001571      1.83328851     2.00000000      20.00000000    EQUAL       -0.5922     20.0       0.5604

FOR H0: VARIANCES ARE EQUAL, F'=     1.73 WITH 12 AND 8 DF      PROB > F'= 0.4421
--------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: SO4

LOC        N             MEAN         STD DEV       STD ERROR        MINIMUM          MAXIMUM    VARIANCES         T       DF   PROB > |T|

6007      28     166.07142857     19.50105139      3.68535231   140.00000000     210.00000000    UNEQUAL    -14.9379     43.4       0.0001
6061      33     304.24242424     48.73591483      8.48383381   190.00000000     390.00000000    EQUAL      -14.0629     59.0       0.0001

FOR H0: VARIANCES ARE EQUAL, F'=     6.25 WITH 32 AND 27 DF      PROB > F'= 0.0001
--------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: NA

LOC        N             MEAN         STD DEV       STD ERROR        MINIMUM          MAXIMUM    VARIANCES         T       DF   PROB > |T|

6007      28     121.78571429     23.52989768      4.44673269    47.00000000     160.00000000    UNEQUAL     -4.2081     58.2       0.0001
6061      33     147.81818182     24.70634350      4.30082236    91.00000000     190.00000000    EQUAL       -4.1910     59.0       0.0001

FOR H0: VARIANCES ARE EQUAL, F'=     1.10 WITH 32 AND 27 DF      PROB > F'= 0.8019
--------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: NH3

LOC        N             MEAN         STD DEV       STD ERROR        MINIMUM          MAXIMUM    VARIANCES         T       DF   PROB > |T|

6007      26       0.04461538      0.04393001      0.00861538              0       0.17000000    UNEQUAL     -0.4492     56.9       0.6550
6061      33       0.05030303      0.05329663      0.00927775              0       0.22000000    EQUAL       -0.4390     57.0       0.6623

FOR H0: VARIANCES ARE EQUAL, F'=     1.47 WITH 32 AND 25 DF      PROB > F'= 0.3229
--------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: SPECCOND

LOC        N             MEAN         STD DEV       STD ERROR        MINIMUM          MAXIMUM    VARIANCES         T       DF   PROB > |T|

6007      28    1047.32142857    102.11179551     19.29731549   825.00000000    1250.00000000    UNEQUAL     -7.5918     55.0       0.0001
6061      33    1305.00000000    160.39989090     27.92203702   875.00000000    1550.00000000    EQUAL       -7.3287     59.0       0.0001

FOR H0: VARIANCES ARE EQUAL, F'=     2.47 WITH 32 AND 27 DF      PROB > F'= 0.0190
```

```
                                    S T A T I S T I C A L   A N A L Y S I S   S Y S T E M         14:04 MONDAY, MARCH 5, 1979    2
                                                        TTEST PROCEDURE
VARIABLE: TDS

LOC         N             MEAN          STD DEV        STD ERROR           MINIMUM           MAXIMUM   VARIANCES          T        DF  PROB > |T|

6007       28     680.60714286      74.19960032      14.02240642      528.00000000      827.00000000   UNEQUAL       -9.2893      54.3      0.0001
6061       32     905.68750000     111.78159509      19.76038097      584.00000000     1080.00000000   EQUAL         -9.0479      58.0      0.0001

FOR H0: VARIANCES ARE EQUAL, F'=     2.27 WITH 31 AND 27 DF      PROB > F'= 0.0335
```

```
                                  S T A T I S T I C A L   A N A L Y S I S   S Y S T E M        16:09 MONDAY, MARCH 5, 1979    1
                                                       TTEST PROCEDURE
VARIABLE: PH
LOC         N             MEAN          STD DEV       STD ERROR         MINIMUM          MAXIMUM    VARIANCES         T        DF   PROB > |T|

6007       28       8.26964286       0.16851161      0.03184570      7.90000000       8.70000000    UNEQUAL     -1.7012      51.8       0.0949 *
6058       27       8.35185185       0.18886375      0.03634685      8.00000000       8.90000000    EQUAL       -1.7048      53.0       0.0941

FOR H0: VARIANCES ARE EQUAL, F'=     1.26 WITH 26 AND 27 DF      PROB > F'= 0.5595
--------------------------------------------------------------------------------------------------------------------------------------------
VARIABLE: B
LOC         N             MEAN          STD DEV       STD ERROR         MINIMUM          MAXIMUM    VARIANCES         T        DF   PROB > |T|

6007       23     199.56521739      35.86315669      7.47798510    130.00000000     250.00000000    UNEQUAL      2.0170      25.8       0.0542 *
6058       24     136.66666667     148.31419841     30.27450898     80.00000000     830.00000000    EQUAL        1.9784      45.0       0.0540

FOR H0: VARIANCES ARE EQUAL, F'=    17.10 WITH 23 AND 22 DF      PROB > F'= 0.0001
--------------------------------------------------------------------------------------------------------------------------------------------
VARIABLE: F
LOC         N             MEAN          STD DEV       STD ERROR         MINIMUM          MAXIMUM    VARIANCES         T        DF   PROB > |T|

6007       28       1.02142857       0.20249763      0.03826846      0.60000000       1.30000000    UNEQUAL     14.6923      34.0       0.0001 *
6058       26       0.42307692       0.07103629      0.01393136      0.30000000       0.60000000    EQUAL       14.2657      52.0       0.0001

FOR H0: VARIANCES ARE EQUAL, F'=     8.13 WITH 27 AND 25 DF      PROB > F'= 0.0001
--------------------------------------------------------------------------------------------------------------------------------------------
VARIABLE: AS
LOC         N             MEAN          STD DEV       STD ERROR         MINIMUM          MAXIMUM    VARIANCES         T        DF   PROB > |T|

6007       24       2.62500000       0.76966961      0.15710815      1.00000000       4.00000000    UNEQUAL      1.8808      28.7       0.0702 *
6058       25       1.64000000       2.49799920      0.49959984      0.00000000      13.00000000    EQUAL        1.8487      47.0       0.0708

FOR H0: VARIANCES ARE EQUAL, F'=    10.53 WITH 24 AND 23 DF      PROB > F'= 0.0001
```

```
                          S T A T I S T I C A L   A N A L Y S I S   S Y S T E M        14:03 MONDAY, MARCH 5, 1979    1
                                                     TTEST PROCEDURE

VARIABLE: MOLY

LOC        N          MEAN        STD. DEV       STD ERROR        MINIMUM         MAXIMUM   VARIANCES          T        DF   PROB > |T|

6007       9    7.22222222      5.01940678      1.67313559     4.00000000     20.00000000   UNEQUAL       0.1630      15.1       0.8727
6058       9    6.77777778      6.45712354      2.15237451     2.00000000     20.00000000   EQUAL         0.1630      16.0       0.8725

FOR H0: VARIANCES ARE EQUAL, F'=    1.65 WITH 8 AND 8 DF     PROB > F'= 0.4920
-------------------------------------------------------------------------------------------------------------------------------------
VARIABLE: SO4

LOC        N          MEAN         STD DEV       STD ERROR        MINIMUM         MAXIMUM   VARIANCES          T        DF   PROB > |T|

6007      28  166.07142857     19.50105139      3.68535231   140.00000000    210.00000000   UNEQUAL     -28.8544      50.5       0.0001
6058      27  334.81481481     23.59438825      4.54074214   290.00000000    390.00000000   EQUAL       -28.9553      53.0       0.0001

FOR H0: VARIANCES ARE EQUAL, F'=    1.46 WITH 26 AND 27 DF     PROB > F'= 0.3309
-------------------------------------------------------------------------------------------------------------------------------------
VARIABLE: NA

LOC        N          MEAN         STD DEV       STD ERROR        MINIMUM         MAXIMUM   VARIANCES          T        DF   PROB > |T|

6007      28  121.78571429     23.52989768      4.44673269    47.00000000    160.00000000   UNEQUAL       1.0831      33.9       0.2864
6058      27  116.66666667      8.32050294      1.60128154   110.00000000    130.00000000   EQUAL         1.0676      53.0       0.2905

FOR H0: VARIANCFS ARE EQUAL, F'=    8.00 WITH 27 AND 26 DF     PROB > F'= 0.0001
-------------------------------------------------------------------------------------------------------------------------------------
VARIABLE: NH3

LOC        N          MEAN         STD DEV       STD ERROR        MINIMUM         MAXIMUM   VARIANCES          T        DF   PROB > |T|

6007      26    0.04461538      0.04393001      0.00861538              0      0.17000000   UNEQUAL       1.2556      43.3       0.2160
6058      25    0.03160000      0.02882129      0.00576426              0      0.09000000   EQUAL         1.2456      49.0       0.2188

FOR H0: VARIANCES ARE EQUAL, F'=    2.32 WITH 25 AND 24 DF     PROB > F'= 0.0426
-------------------------------------------------------------------------------------------------------------------------------------
VARIABLE: SPECCOND

LOC        N          MEAN         STD DEV       STD ERROR        MINIMUM         MAXIMUM   VARIANCES          T        DF   PROB > |T|

6007      28 1047.32142857    102.11179551     19.29731549   825.00000000   1250.00000000   UNEQUAL      -8.3437      50.5       0.0001
6058      27 1251.66666667     78.36060627     15.08050571  1050.00000000   1400.00000000   EQUAL        -8.3038      53.0       0.0001

FOR H0: VARIANCES ARE EQUAL, F'=    1.70 WITH 27 AND 26 DF     PROB > F'= 0.1811
```

```
VARIABLE: PH

LOC         N            MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM    VARIANCES          T         DF   PROB > ^T^

6007       28      8.26964286      0.16851161      0.03184570      7.90000000      8.70000000    UNEQUAL       1.2601       52.0       0.2133
6022       27      8.20925926      0.18607124      0.03580943      7.80000000      8.60000000    EQUAL         1.2624       53.0       0.2123

FOR HO: VARIANCES ARE EQUAL, F'=    1.22 WITH 26 AND 27 DF     PROB > F'= 0.6116
-------------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: B

LOC         N            MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM    VARIANCES          T         DF   PROB > ^T^

6007       23    199.56521739     35.86315669      7.47798510    130.00000000    250.00000000    UNEQUAL      11.8047       40.2       0.0001*
6022       22     89.54545455     26.09091663      5.56260212     70.00000000    200.00000000    EQUAL        11.7223       43.0       0.0001

FOR HO: VARIANCES ARE EQUAL, F'=    1.89 WITH 22 AND 21 DF     PROB > F'= 0.1502
-------------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: F

LOC         N            MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM    VARIANCES          T         DF   PROB > ^T^

6007       28      1.02142857      0.20249763      0.03826846      0.60000000      1.30000000    UNEQUAL      18.3858       33.8       0.0001*
6022       27      0.27407407      0.07121253      0.01370486      0.20000000      0.50000000    EQUAL        18.1221       53.0       0.0001

FOR HO: VARIANCES ARE EQUAL, F'=    8.09 WITH 27 AND 26 DF     PROB > F'= 0.0001
-------------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: AS

LOC         N            MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM    VARIANCES          T         DF   PROB > ^T^

6007       24 ...  2.62500000      0.76966961      0.15710815      1.00000000      4.00000000    UNEQUAL       8.0006       38.4       0.0001*
6022       22      1.13636364      0.46756253      0.09968467      0.00000000      2.00000000    EQUAL         7.8384       44.0       0.0001

FOR HO: VARIANCES ARE EQUAL, F'=    2.71 WITH 23 AND 21 DF     PROB > F'= 0.0250
```

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                         S T A T I S T I C A L   A N A L Y S I S   S Y S T E M      14:03 MONDAY, MARCH 5, 1979    2
                                                    TTEST PROCEDURE
VARIABLE: TDS

LOC        N            MEAN        STD DEV       STD ERROR        MINIMUM          MAXIMUM    VARIANCES         T         DF   PROB > |T|

6007      28    680.60714286    74.19960032     14.02240642   528.00000000     827.00000000    UNEQUAL    -12.6540      41.9       0.0001
6058      25    883.88000000    39.18579675      7.83715935   792.00000000     945.00000000    EQUAL      -12.2490      51.0       0.0001

FOR HO: VARIANCES ARE EQUAL, F'=    3.59 WITH 27 AND 24 DF     PROB > F'= 0.0023
```

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                                    S T A T I S T I C A L   A N A L Y S I S   S Y S T E M        13:39 MONDAY, MARCH 5, 1979   1
                                                          TTEST PROCEDURE
VARIABLE: MOLY
LOC         N           MEAN        STD DEV      STD ERROR        MINIMUM         MAXIMUM   VARIANCES          T        DF   PROB > |T|
6007        9     7.22222222     5.01940678     1.67313559     4.00000000     20.00000000   UNEQUAL       0.7842       7.4       0.4574
6022        5     4.80000000     5.80517011     2.59615100     1.00000000     15.00000000   EQUAL         0.8203      12.0       0.4281
FOR H0: VARIANCES ARE EQUAL, F'=     1.34 WITH 4 AND 8 DF      PROB > F'= 0.6713
--------------------------------------------------------------------------------------------------------------------------------------
VARIABLE: SO4
LOC         N           MEAN        STD DEV      STD ERROR        MINIMUM         MAXIMUM   VARIANCES          T        DF   PROB > |T|
6007       28   166.07142857    19.50105139     3.68535231   140.00000000    210.00000000   UNEQUAL     -38.0648      54.0       0.0001
6022       28   363.21428571    19.25531604     3.63891269   320.00000000    400.00000000   EQUAL       -38.0648      54.0       0.0001
FOR H0: VARIANCES ARE EQUAL, F'=     1.03 WITH 27 AND 27 DF      PROB > F'= 0.9479
--------------------------------------------------------------------------------------------------------------------------------------
VARIABLE: NA
LOC         N           MEAN        STD DEV      STD ERROR        MINIMUM         MAXIMUM   VARIANCES          T        DF   PROB > |T|
6007       28   121.78571429    23.52989768     4.44673269    47.00000000    160.00000000   UNEQUAL       0.4086      52.1       0.6845
6022       28   119.42857143    19.44303850     3.67438890    24.00000000    130.00000000   EQUAL         0.4086      54.0       0.6844
FOR H0: VARIANCES ARE EQUAL, F'=     1.46 WITH 27 AND 27 DF      PROB > F'= 0.3274
--------------------------------------------------------------------------------------------------------------------------------------
VARIABLE: NH3
LOC         N           MEAN        STD DEV      STD ERROR        MINIMUM         MAXIMUM   VARIANCES          T        DF   PROB > |T|
6007       26     0.04461538     0.04393001     0.00861538              0      0.17000000   UNEQUAL       1.7123      42.1       0.0942
6022       24     0.02708333     0.02710353     0.00553249              0      0.10000000   EQUAL         1.6812      48.0       0.0992
FOR H0: VARIANCES ARE EQUAL, F'=     2.63 WITH 25 AND 23 DF      PROB > F'= 0.0228
--------------------------------------------------------------------------------------------------------------------------------------
VARIABLE: SPECCOND
LOC         N           MEAN        STD DEV      STD ERROR        MINIMUM         MAXIMUM   VARIANCES          T        DF   PROB > |T|
6007       28  1047.32142857   102.11179551    19.29731549   825.00000000   1250.00000000   UNEQUAL     -12.6136      37.1       0.0001
6022       28  1313.21428571    44.89110870     8.48362212  1200.00000000   1380.00000000   EQUAL       -12.6136      54.0       0.0001
FOR H0: VARIANCES ARE EQUAL, F'=     5.17 WITH 27 AND 27 DF      PROB > F'= 0.0001
```

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                    S T A T I S T I C A L   A N A L Y S I S   S Y S T E M        13:39 MONDAY, MARCH 5, 1979    2
                                            TTEST PROCEDURE
VARIABLE: TDS

LOC       N            MEAN          STD DEV        STD ERROR         MINIMUM          MAXIMUM    VARIANCES        T        DF   PROB > |T|

6007     28    680.60714286      74.19960032      14.02240642    528.00000000     827.00000000    UNEQUAL    -14.2420     46.3       0.0001
6022     28    918.60714286      48.10200526       9.09042453    703.00000000     968.00000000    EQUAL      -14.2420     54.0       0.0001
FOR H0: VARIANCES ARE EQUAL, F'=     2.38 WITH 27 AND 27 DF      PROB > F'= 0.0279
```

```
                              S T A T I S T I C A L   A N A L Y S I S   S Y S T E M      16:09 MONDAY, MARCH 5, 1979   1
                                                        TTEST PROCEDURE
VARIABLE: PH

LOC        N           MEAN         STD DEV       STD ERROR        MINIMUM          MAXIMUM    VARIANCES         T        DF   PROB > |T|

6022      27     8.20925926      0.18607124      0.03580943     7.80000000       8.60000000    UNEQUAL     -2.7946      52.0       0.0073 *
6058      27     8.35185185      0.18886375      0.03634685     8.00000000       8.90000000    EQUAL       -2.7946      52.0       0.0073

FOR H0: VARIANCES ARE EQUAL, F'=     1.03 WITH 26 AND 26 DF      PROB > F'= 0.9400
------------------------------------------------------------------------------------------------------------------------------------------
VARIABLE: B

LOC        N           MEAN         STD DEV       STD ERROR        MINIMUM          MAXIMUM    VARIANCES         T        DF   PROB > |T|

6022      22    89.54545455     26.09091663      5.56260212    70.00000000     200.00000000    UNEQUAL     -1.5308      24.5       0.1386
6058      24   136.66666667    148.31419841     30.27450898    80.00000000     830.00000000    EQUAL       -1.4682      44.0       0.1492

FOR H0: VARIANCES ARE EQUAL, F'=    32.31 WITH 23 AND 21 DF      PROB > F'= 0.0001
------------------------------------------------------------------------------------------------------------------------------------------
VARIABLE: F

LOC        N           MEAN         STD DEV       STD ERROR        MINIMUM          MAXIMUM    VARIANCES         T        DF   PROB > |T|

6022      27     0.27407407      0.07121253      0.01370486     0.20000000       0.50000000    UNEQUAL     -7.6246      50.9       0.0001 *
6058      26     0.42307692      0.07103629      0.01393136     0.30000000       0.60000000    EQUAL       -7.6242      51.0       0.0001

FOR H0: VARIANCES ARE EQUAL, F'=     1.00 WITH 26 AND 25 DF      PROB > F'= 0.9922
------------------------------------------------------------------------------------------------------------------------------------------
VARIABLE: AS

LOC        N           MEAN         STD DEV       STD ERROR        MINIMUM          MAXIMUM    VARIANCES         T        DF   PROB > |T|

6022      22     1.13636364      0.46756253      0.09968467              0       2.00000000    UNEQUAL     -0.9886      25.9       0.3320
6058      25     1.64000000      2.49799920      0.49959984              0      13.00000000    EQUAL       -0.9303      45.0       0.3572

FOR H0: VARIANCES ARE EQUAL, F'=    28.54 WITH 24 AND 21 DF      PROB > F'= 0.0001
```

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                                   S T A T I S T I C A L   A N A L Y S I S   S Y S T E M        14:09 MONDAY, MARCH 5, 1979    1
                                                          TTEST PROCEDURE

VARIABLE: MOLY

LOC         N            MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM    VARIANCES        T        DF  PROB > |T|

6022        5      4.80000000      5.80517011      2.59615100      1.00000000     15.00000000    UNEQUAL    -0.5865       9.2      0.5717
6058        9      6.77777778      6.45712354      2.15237451      2.00000000     20.00000000    EQUAL      -0.5676      12.0      0.5808

FOR H0: VARIANCES ARE EQUAL, F'=    1.24 WITH 8 AND 4 DF     PROB > F'= 0.8931
------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: SO4

LOC         N            MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM    VARIANCES        T        DF  PROB > |T|

6022       28    363.21428571     19.25531604      3.63891269    320.00000000    400.00000000    UNEQUAL     4.8805      50.2      0.0001
6058       27    334.81481481     23.59438825      4.54074214    290.00000000    390.00000000    EQUAL       4.8987      53.0      0.0001

FOR H0: VARIANCES ARE EQUAL, F'=    1.50 WITH 26 AND 27 DF     PROB > F'= 0.3000
------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: NA

LOC         N            MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM    VARIANCES        T        DF  PROB > |T|

6022       28    119.42857143     19.44303850      3.67438890     24.00000000    130.00000000    UNEQUAL     0.6891      36.8      0.4951
6058       27    116.66666667      8.32050294      1.60128154    110.00000000    130.00000000    EQUAL       0.6803      53.0      0.4993

FOR H0: VARIANCES ARE EQUAL, F'=    5.46 WITH 27 AND 26 DF     PROB > F'= 0.0001
------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: NH3

LOC         N            MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM    VARIANCES        T        DF  PROB > |T|

6022       24      0.02708333      0.02710353      0.00553249               0      0.10000000    UNEQUAL    -0.5653      47.0      0.5746
6058       25      0.03160000      0.02882129      0.00576426               0      0.09000000    EQUAL      -0.5646      47.0      0.5750

FOR H0: VARIANCES ARE EQUAL, F'=    1.13 WITH 24 AND 23 DF     PROB > F'= 0.7707
------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: SPECCOND

LOC         N            MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM    VARIANCES        T        DF  PROB > |T|

6022       28   1313.21428571     44.89110870      8.48362212   1200.00000000   1380.00000000    UNEQUAL     3.5571      41.1      0.0010
6058       27   1251.66666667     78.36060627     15.08050571   1050.00000000   1400.00000000    EQUAL       3.5905      53.0      0.0007

FOR H0: VARIANCES ARE EQUAL, F'=    3.05 WITH 26 AND 27 DF     PROB > F'= 0.0054
```

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                         S T A T I S T I C A L   A N A L Y S I S   S Y S T E M        14:09 MONDAY, MARCH 5, 1979    2
                                                 TTEST PROCEDURE

VARIABLE: TDS

LOC        N           MEAN          STD DEV        STD ERROR         MINIMUM          MAXIMUM     VARIANCES          T        DF   PROB > |T|

6022      28   918.60714286      48.10200526       9.09042453    703.00000000     968.00000000     UNEQUAL       2.8934      50.6       0.0056
6058      25   883.88000000      39.18579675       7.83715935    792.00000000     945.00000000     EQUAL         2.8598      51.0       0.0061

FOR H0: VARIANCES ARE EQUAL, F'=    1.51 WITH 27 AND 24 DF      PROB > F'= 0.3135
```

APPENDIX A5.2.1D

Time Series Analysis UCS FORTELL Box-Jenkins Package

APPENDIX A5.2.1D

Univariate Time Series Analysis

a.) Background

Time series analysis based on the Box Jenkins Technique [Box and Jenkins (1976) and Nelson (1973)] is used to capture all the statistically significant information contained in a series for the purpose of forecasting future trends and values for the series. Techniques are developed and programmed in computer models for both single (univariate) and multiple time series (transfer function). The analyses in this report present only the univariate time series case.

The "Box-Jenkins Philosophy" is captured in their iterative model building process. A model is built up from the data and tested for "fit" in four stages. The model determination stage is called identification. It is followed by parameter estimation. The next step is diagnostic checking (residual analysis) to determine if the model provides an adequate description of the data and that the residuals have been reduced to "white noise." If the checking stage shows that the model is deficient in some way, one returns to the identification stage and repeats the process. When one is satisfied with a model resulting from this iterative process of model building, he may wish to continue to the forecasting of future observations.

The identification stage in time series analysis provides the user with a quantitative measure of the amount of statistical information contained within the data series. This is accomplished through the use of the autocorrelation and partial autocorrelation functions. These functions, as well as some other statistically relevant information, allow the user to choose the initial form of the time series model.

A time series must exhibit stationarity (i.e., the series can be represented by a constant mean) before any modeling can be attempted. A stationary time series can be obtained from the original time series by differencing. Once a stationary series has been obtained, the pattern of the lagged autocorrelations and partial autocorrelations of the stationary series will appear as either a decaying exponential or a series of isolated spikes. This model estimation process can be summarized in terms of the ACF (autocorrelation function) pattern.

ACF	Specify
a. decaying exponential	Autoregressive (AR) model
b. isolated spikes	Moving Average (MA) model
c. lumpy exponential	AR model first, then check residual ACF for MA terms (mixed model)

If the ACF pattern indicates an AR model, "significant" spikes from the plotted Partial Autocorrelation Function (PACF) will define the model. If the ACF pattern indicates an MA model, significant spikes from the ACF will define the model.

The most general form of the Box-Jenkins model has the "autoregressive-integrated moving average" form (ARIMA)

$$(1-\phi B-\phi_2 B^2-\phi B^3-\ldots-\phi_p B^p)\ (1-B)^d z_t = (1-\Theta B-\Theta_2 B^2-\Theta_3 B^3-\ldots-\Theta_q B^q) a_t$$

where $z_t = z_t$ if d, the number of differencing terms, >0, and $z_t = z_t - \mu$ if d = 0, with μ representing the series mean. z_t is the value of series z at time t. The ϕ_m, m = 1,2,3,...,p are autoregressive parameters and appear in the autoregressive factor in the model, while the Θ_m, m = 1,2,3,...,q are moving average parameters and appear in the moving average factor in the model. This model is generally shortened to the form ARIMA (p,d,q), where p and q refer to the order of the autoregressive and moving average processes, respectively, and the d refers to the order of differencing necessary to achieve stationarity. Order refers to the highest time lag for backshift operator B used with p and q and to the highest time lag for differencing with d.

If an optimal model has been specified, the residuals in the estimated model should have been reduced to "white noise" as recognized by two tests:

1. The mean of the residuals should be within reasonable confidence limits of zero. Failure of this test indicates the need for the inclusion of a trend term in the model.

2. There should be no significant terms in the ACF of the lagged residuals. Failure of this test indicates that an insufficient number of parameters have been specified.

b.) Computer Programs

Two different time series computer programs have been used by the C-b Shale Oil Project in its environmental analysis. The United Computing Systems, Inc. FORTELL model was developed by Standard Oil of Ohio; the 00727 models were developed by Ohio State University personnel and are stored on the Occidental Computer System. Both methods are based on the Box-Jenkins technique of time series analysis with user enhancements and provide identical models and modeling results. The following explanation of forecasting is based on the FORTELL model.

FORTELL provides three kinds of forecasting: Variable Lead Time, Fixed Lead Time, and Backward. For each of these types of forecasts, three pieces of information are required:

1. Backward Origin - The backward origin refers to the number of points backward from the last point in the series to be used

as the forecast origin. A backward origin of 0 specifies that the forecast begins with the last point in the series.

2. Lead Time - The lead time of the forecast specifies the number of forecasted points to be calculated out from the origin.

3. Confidence Limits - The confidence limit on the forecast determines a range bounding the forecasted values. This bound indicates to the user that the probability of the actual value, when it occurs, of falling within this bound is equal to the percentage confidence limit chosen.

Variable Lead Time Forecast - a recursive calculation of the projected forecast values from the forecast origin to the end of the forecast. The forecast origin is the last point in the series, minus the background origin chosen, plus one. The end of the forecast is the forecast origin, plus the lead time, minus one.

Fixed Lead Time Forecast - primarily of use as a validation tool which can be used to check for bias in the simulation properties of the model. For this purpose, the lead time should be 1. A lead time greater than 1 results in a series of variable lead time forecasts separated by the lead time chosen, along the length of the portion of the series chosen. The point forecasts are uncorrelated and may be used to check for bias in the model. If the model is unbiased, then the cumulative sum should not steadily increase in either a positive or negative direction.

Backward Forecast - a variable lead time forecast which projects forecast points into the past rather than the future.

A summary page of each of the time series analyses completed for Air Quality and Particulates data from Tract C-b is presented in Tables A6.2.1-4 through A6.2.1-8. These summaries contain basic statistical data for each series as well as a description of the forecasting model used and a summary of forecasting results.

UNIVARIATE TIME SERIES ANALYSIS

USGS STATION WU07

Parameter:	PH
Series Mean:	8.26364
Series Variance:	.022833
Trend:	0.0 at 95% confidence level
Series Minimum:	7.90000
Series Maximum:	8.70000
Chi-Sq. for Data:	19.6666 with 42 d.f.
Chi-Sq. at 95% level:	58.09 with 42 d.f.
Model:	$(Z_t-8.26364)=(1+.25176B^2-.32184B^3+.56853B^4)(1-.10349B^{12})a_t$
Coef. of Det:	.225888
Residual Mean:	-.00117546
Residual Variance:	.0173289
Residual Minimum:	-.328833
Residual Maximum:	.374516
Residual Chi-Sq.:	11.2529 with 39 d.f.
Chi-Sq. at 95% level:	54.56 with 39 d.f.

Discussion:

The PH model is of the moving average form of order four with a one year seasonal component. The seasonal component in this model was forced in order to achieve a more realistic forecast. This model is stationary and no trend is indicated. The original chi-square value of the data alone is relatively low compared to the 95% confidence level, so there is little evidence to believe that for any long term forecasting that there is a better predictor than the series mean.

UNIVARIATE TIME SERIES ANALYSIS

USGS STATION WU07

Parameter: Boron (mg/l)

Series Mean: 205.250

Series Variance: 994.129

Trend: 0.0 at 95% confidence level

Series Minimum: 130.000

Series Maximum: 265.000

Chi-Sq. for Data: 47.1872 with 42 d.f.

Chi-Sq. at 95% level: 58.09 with 42 d.f.

Model: $(1-.60792B)(1-.19592B^{12})(Z_t-205.250)=a_t$

Coef. of Det: .365103

Residual Mean: 1.95220

Residual Variance: 595.544

Residual Minimum: -83.6508

Residual Maximum: 36.1297

Residual Chi-Sq.: 9.58047 with 28 d.f.

Chi-Sq. at 95% level: 41.32 with 28 d.f.

Discussion:

The Boron series is an autoregressive model of order one, the seasonal component is at increments of one year and although in this series the seasonality had to be forced it is never the less considered to be a valid model parameter. There is little doubt that when more data is collected this seasonality will become more pronounced.

The present model is stationary and contains no indication of a deterministic trend, thus for long term forecasting the mean of the series is the best predictor.

UNIVARIATE TIME SERIES ANALYSIS

USGS STATION WU07

Parameter:	Fluoride (mg/l)
Series Mean:	1.02614
Series Variance:	.0390103
Trend:	0.0 at 95% confidence level
Series Minimum:	.500000
Series Maximum:	1.30000
Chi-Sq. for Data:	52.1032 with 42 d.f.
Chi-Sq. at 95% level:	58.09 with 42 d.f.
Model:	$(Z_t-1.02614)=(1+.60940B^1+.62767B^2+.27527B^3)(1+.50633B^{11})a_t$
Coef. of Det:	.453538
Residual Mean:	-.00580097
Residual Variance:	.0194271
Residual Minimum:	-.468227
Residual Maximum:	.227841
Residual Chi-Sq.:	13.5053 with 39 d.f.
Chi-Sq. at 95% level:	54.56 with 39 d.f.

Discussion:

The Flouride series yields a model of the moving average form of order three and with a seasonal component of eleven. This model when expanded will contain a parameter at month twelve, so the season may be considered to be of one year as would be expected.

The present model is stationary and contains no deterministic trend parameter. Due to the stationarity of the series the best predictor for long term forecasting will be the series mean.

UNIVARIATE TIME SERIES ANALYSIS

USGS STATION WU07

Parameter: AS (mg/l)

Series Mean: 2.40909

Series Variance: .433403

Trend: 0.0 at 95% confidence level

Series Minimum: 1.00000

Series Maximum: 4.00000

Chi-Sq. for Data: 43.4855 with 42 d.f.

Chi-Sq. at 95% level: 58.09 with 42 d.f.

Model: $(Z_t-2.40909)=(1+.51295B^1-.27269B^6)(1-.51076B^{12})a_t$

Coef. of Det: 370791

Residual Mean: -.00749787

Residual Variance: .257510

Residual Minimum: -.988554

Residual Maximum: 1.09799

Residual Chi-Sq.: 13.3345 with 40 d.f.

Chi-Sq. at 95% level: 55.76 with 40 d.f.

Discussion:

The AS series produces a moving average model with two basic parameters at lags one and six, in addition, there is a seasonal parameter at lag twelve. This gives a season of one year as desired. The model is stationary and has no trend present.

UNIVARIATE TIME SERIES ANALYSIS

USGS STATION WU22

Parameter:	PH
Series Mean:	8.23295
Series Variance:	.0518539
Trend:	0.0 at 95% confidence level
Series Minimum:	7.1
Series Maximum:	8.6
Chi-Sq. for Data:	11.2228 with 42 d.f.
Chi-Sq. at 95% level:	58.09 with 42 d.f.
Model:	$(Z_t-8.23295))=(1+.28261B^1)a_t$
Coef. of Det:	.0498784
Residual Mean:	.000546660
Residual Variance:	.0481467
Residual Minimum:	-1.06294
Residual Maximum:	.367443
Residual Chi-Sq.:	9.00518 with 42 d.f.
Chi-Sq. at 95% level:	58.09 with 42 d.f.

Discussion:

The model is of the moving average order one form, no seasonal parameter could be forced into this model. Due to the low spike in the autocorrelation function for the one parameter and the low initial chi-square statistic, this series will be best characterized by its mean, i.e. the series appears as a random series about its mean.

The model is stationary and contains no trend parameter.

UNIVARIATE TIME SERIES ANALYSIS

USGS STATION WU22

Parameter: Boron (mg/l)

Series Mean: 106.205

Series Variance: 3511.93

Trend: 0.0 at 95% confidence level

Series Minimum: 70.00

Series Maximum: 325.00

Chi-Sq. for Data: 25.8120 with 42 d.f.

Chi-Sq. at 95% level: 58.09 with 42 d.f.

Model: $(1-.54672B^{1})(1+.15794B^{12})(Z_t-106.205)=a_t$

Coef. of Det: .310868

Residual Mean: 737312

Residual Variance: 1982.18

Residual Minimum: -69.8989

Residual Maximum: 197.582

Residual Chi-Sq.: 6.14870 with 29 d.f.

Chi-Sq. at 95% level: 42.55 with 29 d.f.

Discussion:

The series model is an autoregressive form with parameters at one and twelve. The latter parameter is a forced seasonal parameter included to improve the forecast.

The model is stationary and trendless, and would be best represented in the long run using the mean.

UNIVARIATE TIME SERIES ANALYSIS

USGS STATION WU22

Parameter: FLuoride (mg/l)

Series Mean: .315909

Series Variance: .0783747

Trend: 0.0 at 95% confidence level

Series Minimum: .20

Series Maximum: 2.0

Chi-Sq. for Data: 5.19742 with 42 d.f.

Chi-Sq. at 95% level: 58.09 with 42 d.f.

Model: $(Z_t-.315909)=(1+.26045B^1)a_t$

Coef. of Det: .0394505

Residual Mean: .0000311821

Residual Variance: .0738445

Residual Minimum: -.125703

Residual Maximum: 1.71428

Residual Chi-Sq.: 2.10518 with 41 d.f.

Chi-Sq. at 95% level: 56.93 with 41 d.f.

Discussion:

The developed model is a moving average of order one. The parameter of lag one was not indicated by the identification module but was forced to produce a forecastable model. A seasonal parameter could not be forced. The series is best represented as random noise about its mean value. This is indicated by the lack of information in the autocorrelation function as well as the small chi-squared statistic for the original data series.

No deterministic trend exists in the series.

UNIVARIATE TIME SERIES ANALYSIS

USGS STATION WU22

Parameter: AS (mg/l)

Series Mean: 1.05682

Series Variance: .283269

Trend: 0.0 at 95% confidence level

Series Minimum: 0.0000

Series Maximum: 2.0000

Chi-Sq. for Data: 49.0349 with 42 d.f.

Chi-Sq. at 95% level: 58.09 with 42 d.f.

Model: $(1-.53992B^{1})(Z_{t}-1.05682)=(1+.19146B^{11})a_{t}$

Coef. of Det: .275071

Residual Mean: .00457330

Residual Variance: .200152

Residual Minimum: -1.02614

Residual Maximum: 9.76543

Residual Chi-Sq.: 9.76543 with 21 d.f.

Chi-Sq. at 95% level: 32.66 with 21 d.f.

Discussion:

The AS series yields a mixed model with an autoregressive parameter at one and a moving average parameter at eleven. The seasonal type parameter at lag eleven was forced, i.e. it was not directly indicated by the model identification model.

The series is found to be both stationary and trendless, thus for long term consideration the series mean is the best estimator.

UNIVARIATE TIME SERIES ANALYSIS

USGS STATION WU58

Parameter:	PH
Series Mean:	8.37659
Series Variance:	.0428044
Trend:	0.0 at 95% confidence level
Series Minimum:	7.41000
Series Maximum:	8.9000
Chi-Sq. for Data:	11.3708 with 42 d.f.
Chi-Sq. at 95% level:	58.09 with 42 d.f.

Model:	$(Z_t-8.37659)=(1-.35235B^{13})a_t$
Coef. of Det:	.0692568
Residual Mean:	.00562777
Residual Variance:	.0388937
Residual Minimum:	-.966591
Residual Maximum:	.333409
Residual Chi-Sq.:	10.4119 with 22 d.f.
Chi-Sq. at 95% level:	33.92 with 22 d.f.

Discussion:

The developed model is of the moving average form with a seasonal type parameter at lag thirteen, i.e. approximately one year. The initial chi-square statistic indicated that there was very little modelable information in the series, thus it was to be expected that the above model would not yield significantly variable forecasts. The seasonal parameter was forced. Therefore, due to the series stationarity & the low initial chi-square value the series is best characterized using the mean. The series is also without a significant deterministic mean.

UNIVARIATE TIME SERIES ANALYSIS

USGS STATION WU58

Parameter: Boron (mg/l)

Series Mean: 188.295

Series Variance: 174173

Trend: 0.0 at 95% confidence level

Series Minimum: 90.00

Series Maximum: 2800.00

Chi-Sq. for Data: 3.96482 with 23 d.f.

Chi-Sq. at 95% level: 35.17 with 23 d.f.

Model: $(Z_t-188.295)=(1+.25261B^1)a_t$

Coef. of Det: .0374869

Residual Mean: -.325914

Residual Variance: 163907

Residual Minimum: -.676.577

Residual Maximum: 2447.61

Residual Chi-Sq.: .756545 with 2.2 d.f.

Chi-Sq. at 95% level: 33.92 with 22 d.f.

Discussion:

The model produced is a moving average of order one; this parameter was not indicated by the identification module, it was forced simply to produce a model to forecast from. The series is stationary and trendless. It is best estimated using the series mean and behaves as a random series with mean equal to data series mean. This is seen by examining the forced model and the chi-square statistic which is extremely small.

UNIVARIATE TIME SERIES ANALYSIS

USGS STATION WU58

Parameter: Fluoride (mg/l)

Series Mean: .397727

Series Variance: .0039482

Trend: 0.0 at 95% confidence level

Series Minimum: .3

Series Maximum: .6

Chi-Sq. for Data: 25.4411 with 23 d.f.

Chi-Sq. at 95% level: 35.17 with 23 d.f.

Model: $(1-.46986B^1)(Z_t-.397727)=a_t$

Coef. of Det: .201765

Residual Mean: -.0000280199

Residual Variance: .00314971

Residual Minimum: -.0987951

Residual Maximum: .201205

Residual Chi-Sq.: 4.85830 with 14 d.f.

Chi-Sq. at 95% level: 23.08 with 14 d.f.

Discussion:

The above model is an autoregressive of order one with no trend term. Additionally, the series is stationary and the best estimator for long term forecasting will be the mean of the series.

The series contains little modelable data as is indicated by the initial chi-square statistic and lack of seasonal terms.

UNIVARIATE TIME SERIES ANALYSIS

USGS STATION WU58

Parameter: AS (mg/l)

Series Mean: 1.93183

Series Variance: 6.11152

Trend: 0.0 at 95% confidence level

Series Minimum: 0.0

Series Maximum: 13.0

Chi-Sq. for Data: 31.7755 with 35 d.f.

Chi-Sq. at 95% level: 43.77 with 35 d.f.

Model: $(Z_t-1.93183)=(1+.5704B^1-.14753B^6)a_t$

Coef. of Det: .324379

Residual Mean: .000485539

Residual Variance: 3.95721

Residual Minimum: -1.56266

Residual Maximum: 11.2899

Residual Chi-Sq.: 8.98607 with 21 d.f.

Chi-Sq. at 95% level: 32.66 with 21 d.f.

Discussion:

The model is a stationary moving average with parameters at one and six. The parameter at lag six was forced in order to give the series forecasts a seasonal type appearance.

The series has no deterministic trend at the 95% confidence level and would in any long term forecasting be best represented by using the mean.

UNIVARIATE TIME SERIES ANALYSIS

USGS STATION WU61

Parameter: PH

Series Mean: 8.22500

Series Variance: .0549419

Trend: 0.0 at 95% confidence level

Series Minimum: 7.70000

Series Maximum: 9.20000

Chi-Sq. for Data: 30.3508 with 42 d.f.

Chi-Sq. at 95% level: 58.09 with 42 d.f.

Model: $(1+.41062B^{1}+.27494B^{3})(Z_{t}-8.225)=(1-.18502B^{6})a_{t}$

Coef. of Det: .219029

Residual Mean: -.00626798

Residual Variance: .0422993

Residual Minimum: -.514645

Residual Maximum: .738267

Residual Chi-Sq.: 11.2263 with 37 d.f.

Chi-Sq. at 95% level: 52.16 with 37 d.f.

Discussion:

The PH series is modeled by a mixed model with autoregressive parameters at lags of one and three and a seasonal type moving average parameter at lag six. This seasonal parameter may be interpreted as representing the negative of the actual seasonal parameter at lag twelve, i.e. one year. The model is stationary and without a deterministic trend.

The seasonal parameter was forced in order to develop a forecast which follows the data more closely.

UNIVARIATE TIME SERIES ANALYSIS

USGS STATION WU61

Parameter: Boron (mg/1)

Series Mean: 200.795

Series Variance: 9398.77

Trend: 0.0 at 95% confidence level

Series Minimum: 120.000

Series Maximum: 770.000

Chi-Sq. for Data: 10.8657 with 42 d.f.

Chi-Sq. at 95% level: 58.09 with 42 d.f.

Model: $(Z_t-200.795)=(1+.36876B^1)a_t$

Coef. of Det: .124810

Residual Mean: -.0535268

Residual Variance: 8042.99

Residual Minimum: -155.740

Residual Maximum: 501.525

Residual Chi-Sq.: 2.81552 with 41 d.f.

Chi-Sq. at 95% level: 56.93 with 41 d.f.

Discussion:

The Boron series model is a moving average of order one. An attempt was made to force a seasonal parameter into the model, but all such parameters were estimated to be extremely close to zero, thus the non-seasonal model was accepted. The model developed was stationary with no trend parameter.

Considering the initial and final chi-square statistics, the developed model is probably the best obtainable. Any forecasting beyond one time period is best done using the series mean.

UNIVARIATE TIME SERIES ANALYSIS

USGS STATION WU61

Parameter:	Fluoride (mg/1)
Series Mean:	.677500
Series Variance:	.00744709
Trend:	0.0 at 95% confidence level
Series Minimum:	.50000
Series Maximum:	.90000
Chi-Sq. for Data:	18.806.3 with 42 d.f.
Chi-Sq. at 95% level:	58.07 with 42 d.f.
Model:	$(Z_t-.6775)=(1+.28493B^1+.29495B^8-.22299B^{13})a_t$
Coef. of Det:	.144357
Residual Mean:	.00106531
Residual Variance:	.0060601
Residual Minimum:	-.153992
Residual Maximum:	.192223
Residual Chi-Sq.:	10.4305 with 39 d.f.
Chi-Sq. at 95% level:	54.56 with 39 d.f.

Discussion:

The developed model is of the moving average form with parameters at lags of one, eight and thirteen. The last parameter may be considered to be a seasonal type parameter, and the season may be taken to be on the order of one year. This seasonal parameter was forced and differs little from zero. The above model is stationary and trendless. Due to the chi-square statistic and the stationarity of the series, any long term forecasting would best be accomplished via the series mean.

UNIVARIATE TIME SERIES ANALYSIS

USGS STATION WU61

Parameter: AS (mg/l)

Series Mean: 2.29773

Series Variance: 1.19883

Trend: 0.0 at 95% confidence level

Series Minimum: 0.0000

Series Maximum: 6.0000

Chi-Sq. for Data: 22.4487 with 42 d.f.

Chi-Sq. at 95% level: 58.07 with 42 d.f.

Model: $(Z_t-2.29773)=(1-.30541B^7+61491B^{11})a_t$

Coef. of Det: .164915

Residual Mean: .0190615

Residual Variance: .956252

Residual Minimum: -1.47668

Residual Maximum: 3.06607

Residual Chi-Sq.: 17.7652 with 40 d.f.

Chi-Sq. at 95% level: 55.76 with 40 d.f.

Discussion:

The above model is a moving average with parameters at lags of seven and eleven, these may be considered as seasonal type parameters. When additional data is collected this seasonal aspect should become more distinct.

The series is trendless and stationary, and the mean should be taken as a good indicator for any long term prediction.

APPENDIX A5.2.2

This Appendix is in three parts:

- A5.2.2A - Summary Tables for Linear Regression Analyses
- A5.2.2B - Linear Regression Data for Springs and Seeps
- A5.2.2C - T-TEST Procedure Results for Springs and Seeps

APPENDIX A5.2.2A

Summary Tables for Linear Regression Analyses

List of Tables Appearing in Appendix A5.2.2A

Table A5.2.2A-1

LINEAR REGRESSION OF WATER QUALITY PARAMETERS VS TIME

Location WS01

PARAMETERS	NO. OF OBS.	ESTIMATE OF SLOPE	L L* (95% Conf)	U L* (95% Conf)	T FOR H_0: SLOPE = 0	IS SLOPE SIGNIFICANTLY DIFFERENT FROM ZERO? (95% Conf)
pH	5	0.390	0.158	0.622	4.33	Y
B	4	-0.447	-1.058	0.164	-2.33	N
F	5	-0.200	-0.489	0.089	-1.93	N
As	5	0.00538	-0.00227	0.0130	1.95	N
SO_4	5	-47.1	-85.5	-8.7	-3.40	Y
Na	5	-22.4	-54.1	9.26	-1.96	N
NH_3	3	0.0271	-0.276	0.330	0.38	N
Mo	3	0.00124	-0.0788	0.0812	0.07	N

* Lower and Upper Limits of slope based on standard error of the estimate and the t-statistic for the no. of degrees of freedom.

Table A5.2.2A-2

LINEAR REGRESSION OF WATER QUALITY PARAMETERS VS TIME

Location WS02

PARAMETERS	NO. OF OBS.	ESTIMATE OF SLOPE	L L* (95% Conf)	U L* (95% Conf)	T FOR H_o: SLOPE = 0	IS SLOPE SIGNIFICANTLY DIFFERENT FROM ZERO? (95% Conf)
pH	5	0.00783	-0.211	0,227	0.10	N
B	5	-0.261	-0.703	0.181	-1.64	N
F	5	-0.0780	-0.27	0,114	-1.13	N
As	5	0.00190	-0.00087	0.00467	1.90	N
SO_4	5	-4.86	-19.27	9.55	-0.94	N
Na	5	5.49	0.56	10.4	3.09	Y
NH_3	4	0.0987	-0.0553	0.253	2.04	N
Mo	4	-0.00941	-0.021	0.00219	-2.57	N

* Lower and Upper Limits of slope based on standard error of the estimate and the t-statistic for the no. of degrees of freedom.

Table A5.2.2A-3

LINEAR REGRESSION OF WATER QUALITY PARAMETERS VS TIME

Location WS03

PARAMETERS	NO. OF OBS.	ESTIMATE OF SLOPE	L L* (95% Conf)	U L* (95% Conf)	T FOR H_o: SLOPE = 0	IS SLOPE SIGNIFICANTLY DIFFERENT FROM ZERO? (95% Conf)
pH	13	0.0280	-0,131	0,187	0.38	N
B	9	-0.191	-0.35	-0.032	-2.78	Y
F	13	-0.0316	-0.116	0.0525	-0.82	N
As	13	0.00146	-0.00612	0.00904	0.42	N
SO_4	13	-14.9	-47.4	17.65	-1.00	N
Na	13	-9,48	-18.7	-0.22	-2.23	Y
NH_3	12	0.0383	-0.0437	0.120	1.03	N
Mo	8	-0.0123	-0.0186	-0.00604	-4.64	Y

* Lower and Upper Limits of slope based on standard error of the estimate and the t-statistic for the no. of degrees of freedom.

Table A5.2.2A-4

LINEAR REGRESSION OF WATER QUALITY PARAMETERS VS TIME

Location WS06

PARAMETERS	NO. OF OBS.	ESTIMATE OF SLOPE	L L* (95% Conf)	U L* (95% Conf)	T FOR H_o: SLOPE = 0	IS SLOPE SIGNIFICANTLY DIFFERENT FROM ZERO? (95% Conf)
pH	7	-0.0633	-0.379	0.253	-0.49	N
B	7	-0.316	-0.705	0.073	-2.00	N
F	7	-0.257	-0.671	0.157	-1.52	N
As	6	-0.00162	-0.0124	0.00918	-0.39	N
SO_4	7	-2.33	-19.5	14.9	-0.33	N
Na	7	-1.17	-9.69	7.35	-0.34	N
NH_3	4	-0.0484	-0.257	0.161	-0.74	N
Mo	7	-0.000460	-0.0138	0.0128	-0.08	N

* Lower and Upper Limits of slope based on standard error of the estimate and the t-statistic for the no. of degrees of freedom.

Table A5.2.2A-5

LINEAR REGRESSION OF WATER QUALITY PARAMETERS VS TIME

Location WS07

PARAMETERS	NO. OF OBS.	ESTIMATE OF SLOPE	L L* (95% Conf)	U L* (95% Conf)	T FOR H_o: SLOPE = 0	IS SLOPE SIGNIFICANTLY DIFFERENT FROM ZERO? (95% Conf)
pH	7	-0.0852	-0.278	0.108	-1.08	N
B	7	-0.299	-0.61	0.012	-2.36	N
F	7	-0.169	-0.443	0.105	-1.51	N
As	7	-0.00316	-0.00078	0.0071	1.97	N
SO_4	7	-32.2	-83.8	19.4	-1.53	N
Na	7	-2.83	-8.27	2.61	-1.27	N
NH_3	5	.195	-0.167	0.537	1.59	N
Mo	5	-0.000296	-0.00769	0.00709	-0.11	N

* Lower and Upper Limits of slope based on standard error of the estimate and the t-statistic for the no. of degrees of freedom.

Table A5.2.2A-6

LINEAR REGRESSION OF WATER QUALITY PARAMETERS VS TIME

Location WS09

PARAMETERS	NO. OF OBS.	ESTIMATE OF SLOPE	L L* (95% Conf)	U L* (95% Conf)	T FOR H_o: SLOPE = 0	IS SLOPE SIGNIFICANTLY DIFFERENT FROM ZERO? (95% Conf)
pH	12	-0.0244	-0.172	0.124	-0.36	N
B	7	-0.0928	-0.176	-0.0096	-2.73	Y
F	12	-0.136	-0.396	0.124	-1.15	N
As	11	0.00245	-0.00915	0.0141	0.47	N
SO_4	12	-30.6	-71.9	10.7	-1.63	N
Na	12	-2.04	-16.3	12.3	-0.31	N
NH_3	10	-0.0187	-0.0952	0.0578	-0.55	N
Mo	6	-0.0425	-0.0903	0.0053	-2.28	N

* Lower and Upper Limits of slope based on standard error of the estimate and the t-statistic for the no. of degrees of freedom.

Table A5.2.2A-7

LINEAR REGRESSION OF WATER QUALITY PARAMETERS VS TIME

Location WS10

PARAMETERS	NO. OF OBS.	ESTIMATE OF SLOPE	L L* (95% Conf)	U L* (95% Conf)	T FOR H_o: SLOPE = 0	IS SLOPE SIGNIFICANTLY DIFFERENT FROM ZERO? (95% Conf)
pH	9	0.0747	-0.106	0.256	0.95	N
B	7	-0.0832	-0.213	0.0468	-1.56	N
F	9	-0.148	-0.386	0.09	-1.44	N
As	9	0.00405	0.00057	0.00753	2.68	Y
SO_4	9	17.3	9.29	25.4	4.97	Y
Na	9	1.55	-1.85	4.95	1.05	N
NH_3	7	-0.0320	-0.133	0.069	-0.78	N
Mo	4	-0.00262	-0.0258	0.0206	-0.36	N

* Lower and Upper Limits of slope based on standard error of the estimate and the t-statistic for the no. of degrees of freedom.

APPENDIX A5.2.2B

Linear Regression Data for Springs and Seeps

```
------------------------------------------------------------ LOC=WS01 ------------------------------------------------------------

OBS YR MO LIST TOC PHENOLS PH  B      F    AS      YRMO     PRED1      PRED2    PRED3       PRED4        RESID1   RESID2    RESID3     RESID4

 98 74 10   1   6     .     7.9 1.40 0.9 0.003 74.7500 7.76339   1.12707 0.697030 -0.0020529  0.13661  0.27293  0.20297  0.0050529
 99 76  5   2   .     .     8.3 0.03 0.2 0.001 76.3333 8.38099   0.41908 0.380022  0.0064622 -0.08099 -0.38908 -0.18002 -0.0054622
100 76  6   3   .     .     8.4   .  0.2 0.001 76.4167 8.41350   0.38182 0.363337  0.0069104 -0.01350   .      -0.16334 -0.0059104
101 76 10   4   .   0.014   8.3 0.02 0.2 0.010 76.7500 8.56352   0.23276 0.296598  0.0087030 -0.24352 -0.21276 -0.09660  0.0012970
102 77 12   5   .     .     9.2 0.04 0.3 0.020 77.9167 8.99860  -0.28892 0.063013  0.0149773  0.20140  0.32892  0.23699  0.0050227

------------------------------------------------------------ LOC=WS02 ------------------------------------------------------------

OBS YR MO LIST TOC PHENOLS PH   B     F    AS      YRMO     PRED1      PRED2    PRED3       PRED4        RESID1    RESID2    RESID3     RESID4

103 74 10   1   3     .     8.0 1.20 0.6 0.004 74.7500 8.18722   0.70085 0.387477 0.00129892 -0.18722  0.49915  0.21252  0.0027011
104 75  9   2   1     .     8.4 0.10 0.1 0.002 75.6667 8.19439   0.46129 0.315934 0.00303932  0.20561 -0.36129 -0.21593 -0.0010393
105 76  5   3   .     .     8.1 0.02 0.2 0.001 76.3333 8.19961   0.28707 0.263902 0.00430507 -0.09961 -0.26707 -0.06390 -0.0033051
106 76 10   4   .   0.022   8.4 0.01 0.2 0.005 76.7500 8.20287   0.17818 0.231383 0.00509616  0.19713 -0.16818 -0.03138 -0.0009962
107 78  6   5   .   0.043   8.1 0.04 0.2 0.010 78.4167 8.21592  -0.25738 0.101305 0.00826053 -0.11592  0.29738  0.09870  0.0017395

------------------------------------------------------------ LOC=WS03 ------------------------------------------------------------

OBS YR MO LIST TOC PHENOLS PH  B      F    AS      YRMO     PRED1       PRED2    PRED3      PRED4       RESID1    RESID2    RESID3    RESID4

108 74 10   1   4     .     7.6 1.10 0.7 0.003 74.7500 8.17342   0.620172 0.318584 0.0067801 -0.57342  0.47983  0.38142 -0.0037801
109 75  9   2   1     .     8.4 0.40 0.2 0.004 75.6667 8.19905   0.445205 0.289654 0.0081158  0.20095 -0.04521 -0.08965 -0.0041158
110 76  2   3   .     .     8.5 0.05 0.1 0.010 76.0833 8.21070   0.365675 0.276504 0.0087230  0.28930 -0.31566 -0.17650  0.0012770
111 76  4   4   .     .     8.3   .  0.2 0.050 76.2500 8.21536   0.333863 0.271244 0.0089659  0.08464   .      -0.07124  0.0410341
112 76  5   5   .   0.010   8.3 0.07 0.2 0.001 76.3333 8.21769   0.317957 0.268614 0.0090873  0.08231 -0.24796 -0.06861 -0.0080873
113 76  6   6   .     .     8.5   .  0.2 0.001 76.4167 8.22002   0.302051 0.265984 0.0092088  0.27998   .      -0.06598 -0.0082088
114 76  7   7   .     .     7.8   .  0.2 0.001 76.5000 8.22235   0.286145 0.263354 0.0093302 -0.42235   .      -0.06335 -0.0083302
115 76  8   8   .     .     8.5   .  0.2 0.001 76.5833 8.22468   0.270239 0.260725 0.0094516  0.27532   .      -0.06072 -0.0084516
116 76 10   9   .   0.011   8.4 0.00 0.2 0.006 76.7500 8.22934   0.238427 0.255465 0.0096945  0.17066 -0.23843 -0.05546 -0.0036945
117 77 12  10   .     .     8.2 0.04 0.2 0.020 77.9167 8.26195   0.015742 0.218645 0.0113946 -0.06195  0.02426 -0.01865  0.0086054
118 78  4  11   .   0.007   8.3 0.04 0.4 0.010 78.2500 8.27127  -0.047883 0.208125 0.0118803  0.02873  0.08788  0.19187 -0.0018303
119 78  6  12   .   0.001   8.0 0.04 0.2 0.010 78.4167 8.27593  -0.079695 0.202865 0.0121232 -0.27593  0.11969 -0.00287 -0.0021232
120 78  7  13   .   0.010   8.2 0.04 0.3 0.010 78.5000 8.27826  -0.095601 0.200235 0.0122446 -0.07826  0.13560  0.09976 -0.0022446

------------------------------------------------------------ LOC=WS04 ------------------------------------------------------------

OBS YR MO LIST TOC PHENOLS PH   B     F   AS      YRMO     PRED1       PRED2    PRED3      PRED4      RESID1     RESID2    RESID3    RESID4

121 74 10   1   3     .     7.8 1.20 0.6   .    74.7500 8.07007   0.704271 0.392278 0.0008391 -0.27007  0.49573  0.20772    .
122 75  9   2   1     .     8.4 0.10 0.1 0.003 75.6667 8.13246   0.517407 0.322545 0.0031406  0.26754 -0.41741 -0.22255 -0.00014061
123 76  5   3   .     .     8.3 0.06 0.2 0.005 76.3333 8.17784   0.381506 0.271830 0.0048144  0.12216 -0.32151 -0.07183  0.00018560
124 78  6   4   .   0.01    8.2 0.20 0.2 0.010 78.4167 8.31964  -0.043184 0.113346 0.0100450 -0.11964  0.24318  0.08665 -0.00004499
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----------------------------------------------------------- LOC=WS06 ------------------------------------------------------------

OBS  YR  MO  DISSOXY  MOLY  SO4  NA   NH3    YRMO      PRED1      PRED2     PRED3     PRED4      RESID1      RESID2   RESID3  RESID4

125  74  10     .     0.01  360  160  0.10  74.7500  0.0207828  360.683  143.996  0.237080  -0.010783   -0.683   16.004  -0.13708
126  75   5     .     0.00  360  140   .    75.3333  0.0205146  359.323  143.312  0.208874  -0.020515    0.677   -3.312    .
127  75   9     .     0.05  350  140  0.40  75.5667  0.0203613  358.546  142.921  0.192757   0.029639   -8.546   -2.921   0.20724
128  76   5     .     0.03  346  133   .    76.3333  0.0200547  356.992  142.140  0.160522   0.009945  -10.992   -9.140    .
129  76  10     .     0.02  374  128  0.10  76.7500  0.0198631  356.021  141.651  0.140375   0.000137   17.979  -13.651  -0.04038
130  77  12    7.5    0.02  387  143   .    77.9167  0.0193266  353.301  140.283  0.083964   0.000673   33.699    2.717    .
131  78   6    4.2    0.01  320  150  0.03  78.4167  0.0190967  352.135  139.697  0.059788  -0.009097  -32.135   10.303  -0.02979

----------------------------------------------------------- LOC=WS07 ------------------------------------------------------------

OBS  YR  MO  DISSOXY  MOLY  SO4  NA   NH3    YRMO      PRED1      PRED2     PRED3     PRED4      RESID1      RESID2   RESID3  RESID4

132  74  10     .       .   380  150  0.10  74.7500  0.0147901  397.657  140.316  -0.019910      .         -17.66   9.6836   0.11991
133  75   9     .     0.01  380  130  0.20  75.6667  0.0145185  368.184  137.722   0.158574  -0.0045185   11.82  -7.7221   0.04143
134  76   5     .       .   357  133   .    76.3333  0.0143210  346.750  135.635   0.288381      .          10.25  -2.6354    .
135  76  10     .     0.02  381  130  0.10  76.7500  0.0141975  333.353  134.656   0.369510   0.0058025   47.65  -4.6563  -0.26951
136  77  12    9.0    0.02  156  127   .    77.9167  0.0138519  295.843  131.355   0.596671   0.0061481 -139.84  -4.3547    .
137  78   4    8.3    0.01  320  140  0.28  78.2500  0.0137531  285.126  130.411   0.611574  -0.0037531   34.87   9.5886  -0.33157
138  78   7    5.5    0.01  330  130  1.20  78.5000  0.0136790  277.089  129.704   0.710252  -0.0036790   52.91   0.2961   0.48975

----------------------------------------------------------- LOC=WS08 ------------------------------------------------------------

OBS  YR  MO  DISSOXY  MOLY  SO4  NA   NH3    YRMO      PRED1      PRED2     PRED3     PRED4      RESID1     RESID2   RESID3   RESID4

139  74  10     .     0.06  350  140  0.10  74.7500  0.0444296  352.288  122.505  0.035401   0.015570   -2.288   17.495   0.06460
140  75   9     .     0.02  330  110  0.20  75.6667  0.0337433  341.955  124.015  0.158930  -0.013743  -11.955  -14.015   0.04107
141  75  10     .     0.01  354  111  0.10  76.7500  0.0211141  329.742  125.799  0.305920  -0.011114   24.258  -14.799  -0.20592
142  78   7    6.2    0.01  300  140  0.64  78.5000  0.0007130  310.015  128.681  0.540749   0.009287  -10.015   11.319   0.09925

----------------------------------------------------------- LOC=WS09 ------------------------------------------------------------

OBS  YR  MO  DISSOXY  MOLY   SO4  NA   NH3    YRMO      PRED1      PRED2     PRED3     PRED4      RESID1     RESID2   RESID3   RESID4

143  74  10     .     0.200  350  150  0.10  74.7500   0.131392  376.589  125.453  0.111262   0.068608   -26.59   24.547  -0.011262
144  75   9     .       .    340  130   .    75.6667   0.092435  349.527  123.586  0.094118       .       -9.53    6.414      .
145  76   2     .     0.030  358  120  0.02  76.0833   0.074728  335.772  122.738  0.086325  -0.044728    22.23   -2.738  -0.066325
146  76   4     .       .    370  124  0.05  76.2500   0.067645  330.670  122.399  0.083208       .        39.33    1.601  -0.033208
147  76   5     .     0.009  318  120  0.30  76.3333   0.064103  328.119  122.229  0.081650  -0.055103   -10.12   -2.229   0.218350
148  76   6     .       .    362  122  0.03  76.4167   0.060562  325.568  122.060  0.080091       .        36.43   -0.060  -0.050091
149  76   7     .       .    356  120  0.02  76.5000   0.057020  323.017  121.890  0.078532       .        32.98   -1.890  -0.058532
150  76   8     .       .    196   68  0.12  76.5833   0.053479  320.466  121.720  0.076974       .      -124.47  -53.720   0.043026
151  76   9     .       .    366  120  0.02  76.6667   0.049937  317.915  121.551  0.075415       .        48.09   -1.551  -0.055415
152  76  10     .     0.020  350  118  0.10  76.7500   0.046396  315.364  121.381  0.073857  -0.026396    34.64   -3.381   0.026143
153  77  12    6.1    0.020  190  140   .    77.9167  -0.003185  279.649  119.006  0.052037   0.023185   -89.65   20.994      .
154  78   6    7.0    0.010  310  130  0.03  78.4167  -0.024434  264.343  117.988  0.042686   0.034434    45.66   12.012  -0.012686
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                                                      REGRESSION OF WATER QUALITY PARAMETERS VS TIME       10:31 TUESDAY, DECEMBER 12, 1978  105

 ------------------------------------------------------------- LOC=WS10 ---------------------------------------------------------------------

 OBS  YR  MO  DISSOXY  MOLY  SO4  NA   NH3    YRMO       PRED1      PRED2     PRED3     PRED4      RESID1      RESID2   RESID3   RESID4

 155  74  10     .     0.02  310  120  0.10  74.7500  0.0307759  304.460  110.909  0.160032  -0.010776    5.540   9.0914  -0.060032
 156  75   5     .      .    320  110   .    75.3333  0.0292502  314.574  111.815  0.141368      .        5.426  -1.8149     .
 157  75   9     .      .    320  110  0.20  75.6667  0.0283784  320.354  112.333  0.130734      .       -0.354  -2.3328   0.069266
 158  76   5     .      .    310  112  0.30  76.3333  0.0266347  331.913  113.369  0.109426      .      -21.913  -1.3685   0.190574
 159  76   6     .      .    342  111  0.01  76.4167  0.0264167  333.358  113.496  0.106762      .        8.642  -2.4980  -0.096763
 160  76   7     .      .    341  109  0.01  76.5000  0.0261988  334.803  113.627  0.104099      .        6.197  -4.6275  -0.094099
 161  76  10     .     0.05  329  110  0.10  76.7500  0.0255449  339.137  114.016  0.096108   0.024455  -10.137  -4.0159   0.003892
 162  77  12    5.2    0.02  354  120   .    77.9167  0.0224935  355.366  115.823  0.058820  -0.002493   -5.366   4.1715     .
 163  78   6   11.2    0.01  380  120  0.03  78.4167  0.0211857  368.035  116.605  0.042839  -0.011186   11.965   3.3947  -0.012839
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------------------------------------------------------ LOC=WS01 -----------------------------------------------------

OBS  YR  MO  DISSOXY  MOLY  SO4  NA   NH3    YRMO      PRED1      PRED2    PRED3    PRED4      RESID1     RESID2   RESID3   RESID4

 98  74  10     .       .   440  200  0.10  74.7500  0.0205498  457.673  177.657  0.113548      .         -17.673   22.343  -0.013548
 99  76   5     .     0.01  373  123   .    76.3333  0.0225086  392.909  142.237  0.156452  -0.012509     -9.909  -19.237      .
100  76   6     .       .   397  122  0.24  76.4167  0.0226117  378.985  140.373  0.158710      .          18.015  -18.373   0.081290
101  76  10     .     0.04  401  122  0.10  76.7500  0.0230241  363.287  132.916  0.167742   0.014976     37.713  -10.916  -0.067742
102  77  12     6     0.02  230  133   .    77.9167  0.0244674  308.545  106.817  0.199555  -0.004467    -78.545   26.183      .

------------------------------------------------------ LOC=WS02 -----------------------------------------------------

OBS  YR  MO  DISSOXY  MOLY  SO4  NA   NH3    YRMO      PRED1      PRED2    PRED3    PRED4      RESID1     RESID2   RESID3   RESID4

103  74  10     .       .   340  110  0.1   74.7500  0.0417116  349.541  105.840  0.062526      .          -9.541   4.1599  0.03747
104  75   9     .     0.04  340  110  0.2   75.6667  0.0330860  345.086  110.869  0.153018   0.0069140    -5.086  -0.8686  0.04698
105  76   5     .     0.02  354  113   .    76.3333  0.0268128  341.843  114.526  0.218830  -0.0068128    12.157  -1.5257     .
106  76  10     .     0.02  354  111  0.1   76.7500  0.0228921  339.817  116.811  0.259963  -0.0028921    14.183  -5.8114 -0.15996
107  78   6    6.1    0.01  320  130  0.5   78.4167  0.0072091  331.714  125.954  0.424495   0.0027909   -11.714   4.0458  0.07551

------------------------------------------------------ LOC=WS03 -----------------------------------------------------

OBS  YR  MO  DISSOXY  MOLY  SO4  NA   NH3    YRMO      PRED1      PRED2    PRED3    PRED4      RESID1     RESID2   RESID3   RESID4

108  74  10     .       .   370  200  0.10  74.7500  0.0555897  417.407  157.982  0.081640      .         -47.41   42.018   0.01836
109  75   9     .     0.05  400  140  0.40  75.6667  0.0443265  403.750  149.293  0.116759   0.005673     -3.75   -9.293   0.28324
110  76   2     .     0.04  337  131  0.02  76.0833  0.0392069  397.543  145.344  0.132722   0.000793    -60.54  -14.344  -0.11272
111  76   4     .       .   435  135  0.05  76.2500  0.0371591  395.059  143.764  0.139107      .          39.94   -8.764  -0.08911
112  76   5     .     0.02  398  129  0.30  76.3333  0.0361352  393.818  142.974  0.142300  -0.016135      4.18  -13.974   0.15770
113  76   6     .       .   415  129  0.01  76.4167  0.0351112  392.576  142.184  0.145492      .          22.42  -13.184  -0.13549
114  76   7     .       .   417  132  0.01  76.5000  0.0340873  391.335  141.394  0.148685      .          25.67   -9.394  -0.13869
115  76   8     .       .   415  138  0.12  76.5833  0.0330634  390.093  140.604  0.151878      .          24.91   -2.604  -0.03188
116  76  10     .     0.04  424  135  0.10  76.7500  0.0310155  387.610  139.025  0.158263   0.008984     36.39   -4.025  -0.05826
117  77  12    7.2    0.02  218  142   .    77.9167  0.0166806  370.229  127.966  0.202960   0.003319   -152.23   14.034      .
118  78   4    9.4    0.01  320  140  0.12  78.2500  0.0125849  365.262  124.806  0.215730  -0.002585    -45.26   15.194  -0.09573
119  78   7    7.5    0.01  400  130  0.35  78.5000  0.0095132  361.553  122.436  0.225309   0.000487     38.45    7.564   0.12469
120  78   6    6.6    0.01  430  120  0.30  78.4167  0.0105371  362.778  123.226  0.222315  -0.000537     67.22   -3.226   0.07768

------------------------------------------------------ LOC=WS04 -----------------------------------------------------

OBS  YR  MO  DISSOXY  MOLY   SO4   NA   NH3    YRMO      PRED1      PRED2    PRED3    PRED4      RESID1      RESID2   RESID3   RESID4

121  74  10     .     0.010  290   90  0.10  74.7500  0.0164395  300.622   97.237  0.116156  -0.0064395   -10.622  -7.2374  -0.016156
122  75   9     .     0.030  300  100  0.20  75.6667  0.0148403  327.158  104.677  0.178462   0.0151597   -27.158  -4.6773   0.021538
123  76   5     .     0.005  401  129   .    76.3333  0.0136773  346.456  110.088  0.223776  -0.0086773    54.544  18.9116      .
124  78   6    7.5    0.010  390  120  0.36  78.4167  0.0100429  400.706  126.997  0.365385  -0.0000429   -10.706  -6.9971  -0.005385
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76.
1007

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------------------------------------------------------------ LOC=VS06 ------------------------------------------------------------

OBS YR MO LIST TOC PHENOLS PH   B     F     AS      YRMO     PRED1     PRED2   PRED3     PRED4      RESID1    RESID2    RESID3   RESID4

125 74 10   1    3     .    8.2 1.60 2.10 0.030 74.7500 8.09345  0.97711 1.15141 0.0140605  0.10655  0.62289  0.94859  0.015939
126 75  5   2    .     .    7.3 0.10 0.60   .   75.3333 8.05653  0.79256 1.00163 0.0131153 -0.75653 -0.69258 -0.40163    .
127 75  9   3    3     .    8.4 1.10 0.40 0.002 75.6667 8.03544  0.68713 0.91604 0.0125753  0.36456  0.41267 -0.51604 -0.010575
128 76  5   4    .     .    8.2 0.04 0.50 0.001 76.3333 7.99325  0.47623 0.74485 0.0114951  0.20675 -0.43623 -0.24485 -0.010495
129 76 10   5    .   0.009  8.3 0.10 0.40 0.003 76.7500 7.96688  0.34442 0.63786 0.0106200  0.33312 -0.24442 -0.23766 -0.007820
130 77 12   6    .     .    7.8 0.04 0.51 0.020 77.9167 7.89305 -0.02465 0.33830 0.0089297 -0.09305  0.06465  0.17170  0.011070
131 78  6   7    .   0.003  7.7 0.09 0.49 0.010 78.4167 7.86141 -0.18282 0.20991 0.0081195 -0.16141  0.27282  0.28009  0.001880

------------------------------------------------------------ LOC=VS07 ------------------------------------------------------------

OBS YR MO LIST TOC PHENOLS PH   B     F     AS      YRMO     PRED1     PRED2   PRED3      PRED4      RESID1    RESID2    RESID3     RESID4

132 74 10   1    6     .    8.1 1.60 1.50 0.004 74.7500 8.32447  0.92790 0.909441 0.0004068 -0.22447  0.67210  0.59056  0.0035932
133 75  9   2    1     .    8.4 0.20 0.30 0.003 75.6667 8.24635  0.65350 0.754206 0.0033044  0.15365 -0.45350 -0.45421 -0.0003044
134 76  5   3    .     .    8.1 0.10 0.40 0.001 76.3333 8.18953  0.45393 0.641309 0.0054118 -0.08953 -0.35393 -0.24131 -0.0044118
135 76 10   4    .   0.007  8.4 0.02 0.30 0.002 76.7500 8.15402  0.32920 0.570748 0.0067289  0.24598 -0.30920 -0.27075 -0.0047289
136 77 12   5    .     .    8.4 0.04 0.40 0.020 77.9167 8.05458 -0.02004 0.373177 0.0104168  0.34542  0.06004  0.02682  0.0095832
137 78  4   6    .   0.004  7.9 0.03 0.53 0.010 78.2500 8.02618 -0.11982 0.316728 0.0114705 -0.12618  0.14992  0.21327 -0.0014705
138 78  7   7    .   0.010  7.7 0.04 0.41 0.010 78.5000 8.00487 -0.19466 0.274391 0.0122608 -0.30487  0.23466  0.13561 -0.0022608

------------------------------------------------------------ LOC=VS08 ------------------------------------------------------------

OBS YR MO LIST TOC PHENOLS PH   B     F     AS      YRMO     PRED1    PRED2     PRED3      PRED4       RESID1    RESID2     RESID3    RESID4

139 74 10   1    3     .    7.9 0.20 1.70   .    74.7500 8.25134 0.202709 1.07872 0.00636693 -0.35134 -0.002709  0.62128     .
140 75  9   2    1     .    8.3 0.20 0.20 0.010 75.6667 8.11310 0.157219 0.84980 0.00676557  0.18690  0.042781 -0.64990  0.0032346
141 76 10   3    .   0.037  8.4 0.04 0.30 0.002 76.7500 7.94973 0.103458 0.57926 0.00723669  0.45027 -0.063458 -0.27926 -0.0052367
142 78  7   4    .   0.002  7.4 0.04 0.45 0.010 78.5000 7.68583 0.016613 0.14222 0.00799773 -0.28583  0.023387  0.30778  0.0020023

------------------------------------------------------------ LOC=VS09 ------------------------------------------------------------

OBS YR MO LIST TOC PHENOLS PH  B     F   AS      YRMO     PRED1      PRED2    PRED3      PRED4      RESID1    RESID2    RESID3  RESID4

143 74 10   1    3     .    8.1 0.40 1.5 0.002 74.7500 8.23502  0.300757 0.716966 0.0039002 -0.13502  0.09924  0.78503 -0.0019002
144 75  9   2    .     .    7.8 0.30 0.5   .   75.6667 8.21267  0.215702 0.592202 0.0061495 -0.41267  0.08430 -0.09220    .
145 76  2   3    .     .    8.3 0.02 0.3 0.002 76.0833 8.20250  0.177041 0.535491 0.0071719  0.09750 -0.15704 -0.23549 -0.0051719
146 76  4   4    .     .    8.3   .  0.4 0.050 76.2500 8.19844  0.161577 0.512807 0.0075809  0.10156    .     -0.11281  0.0424191
147 76  5   5    .   0.010  8.2 0.08 0.4 0.001 76.3333 8.19641  0.153845 0.501465 0.0077853  0.00359 -0.07384 -0.10147 -0.0067853
148 76  6   6    .     .    8.3   .  0.2 0.001 76.4167 8.19439  0.146112 0.490123 0.0079898  0.10562    .     -0.29012 -0.0069898
149 76  7   7    .     .    8.2   .  0.3 0.000 76.5000 8.19234  0.138380 0.478781 0.0081943  0.00766    .     -0.17678 -0.0081943
150 76  8   8    .     .    8.3   .  0.2 0.001 76.5833 8.19031  0.130648 0.467439 0.0083988  0.10969    .     -0.26744 -0.0073988
151 76  9   9    .     .    8.4   .  0.4 0.001 76.6667 8.18828  0.122916 0.456096 0.0086033  0.21172    .     -0.05610 -0.0076033
152 76 10  10    .   0.031  8.4 0.06 0.2 0.005 76.7500 8.18625  0.115184 0.444754 0.0088077  0.21375 -0.05518 -0.24475 -0.0038077
153 77 12  11    .     .    8.2 0.04 0.9 0.020 77.9167 8.15780  0.006933 0.285964 0.0116705  0.04220  0.03307  0.61404  0.0083295
154 78  6  12    .   0.005  7.8 0.03 0.4 0.010 78.4167 8.14560 -0.039461 0.217911 0.0128974 -0.34560  0.06946  0.18209 -0.0023974
```

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                                                     REGRESSION OF WATER QUALITY PARAMETERS VS TIME        13:39 MONDAY, DECEMBER 11, 1978  106

----------------------------------------------------------------- LOC=WS10 ------------------------------------------------------------------

OBS YR MO LIST TOC PHENOLS PH  B     F     AS     YRMO     PRED1    PRED2     PRED3      PRED4      RESID1   RESID2'   RESID3     RESID4

155 74 10   1   6     .     7.9 0.60 1.40 0.002 74.7500 8.06169 0.313049 0.710760 -0.0026714 -0.16169  0.28695  0.68924  0.0046714
156 75  5   2   .   0.010   7.9 0.10 0.40 0.001 75.3333 8.10524 0.264522 0.624522 -0.0003111 -0.20524 -0.16452 -0.22452  0.0013111
157 75  9   3   1     .     8.3 0.10 0.30 0.001 75.6667 8.13013 0.236792 0.575243  0.0010377  0.16987 -0.13679 -0.27524 -0.0000377
158 76  5   4   .     .     8.2 0.06 0.40 0.001 76.3333 8.17990 0.181332 0.476684  0.0037352  0.02010 -0.12133 -0.07668 -0.0027352
159 76  6   5   .     .     8.4  .   0.20 0.001 76.4167 8.18612 0.174400 0.464364  0.0040724  0.21388   .       -0.26436 -0.0030724
160 76  7   6   .     .     8.1  .   0.30 0.000 76.5000 8.19235 0.167467 0.452045  0.0044095 -0.09235   .       -0.15204 -0.0044095
161 76 10   7   .   0.007   8.4 0.20 0.30 0.002 76.7500 8.21101 0.146670 0.415085  0.0054211  0.16899  0.05333 -0.11509 -0.0034211
162 77 12   8   .     .     8.6 0.04 0.43 0.020 77.9167 8.29811 0.049615 0.242608  0.0101417  0.30189 -0.00961  0.18739  0.0098583
163 78  6   9   .   0.008   7.9 0.10 0.40 0.010 78.4167 8.33544 0.008020 0.168689  0.0121649 -0.43544  0.09198  0.23131 -0.0021649

----------------------------------------------------------------- LOC=WS11 ------------------------------------------------------------------

     OBS  YR  MO  LIST  TOC  PHENOLS  PH   B   F   AS    YRMO    PRED1  PRED2  PRED3  PRED4  RESID1  RESID2  RESID3  RESID4

     164  75  5    1     .      .     7.4  .  0.2  .   75.3333   7.4     .     0.2     .      0       .       0       .
```

APPENDIX A5.2.2C

T-TEST Procedure Results
for
Spring and Seeps WS01, WS03, WS06, WS07

```
                         S T A T I S T I C A L   A N A L Y S I S   S Y S T E M    9:01 TUESDAY, FEBRUARY 27, 1979    1
                                                   TTEST PROCEDURE

VARIABLE: PH

LOC        N          MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES         T        DF   PROB > |T|

WS03      13    8.23076923     0.27804261     0.07711514     7.60000000     8.50000000   UNEQUAL      1.4508       9.3       0.1799
WS06       7    7.98571429     0.39761192     0.15028318     7.30000000     8.40000000   EQUAL        1.6190      18.0       0.1228

FOR HO: VARIANCES ARE EQUAL, F'=     2.05 WITH 6 AND 12 DF      PROB > F'= 0.2747
--------------------------------------------------------------------------------------------------------------------------------

VARIABLE: B

LOC        N          MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES         T        DF   PROB > |T|

WS03       9    0.19777778     0.35912316     0.11970772     0.00000000     1.10000000   UNEQUAL     -0.8926       8.9       0.3956
WS06       7    0.43857143     0.63964648     0.24176364     0.04000000     1.60000000   EQUAL       -0.9574      14.0       0.3546

FOR HO: VARIANCES ARE EQUAL, F'=     3.17 WITH 6 AND 8 DF      PROB > F'= 0.1346
--------------------------------------------------------------------------------------------------------------------------------

VARIABLE: F

LOC        N          MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES         T        DF   PROB > |T|

WS03      13    0.25384615     0.15063966     0.04177992     0.10000000     0.70000000   UNEQUAL     -1.9498       6.4       0.0964
WS06       7    0.71428571     0.61492160     0.23241852     0.40000000     2.10000000   EQUAL       -2.6140      18.0       0.0176

FOR HO: VARIANCES ARE EQUAL, F'=    16.66 WITH 6 AND 12 DF      PROB > F'= 0.0001
--------------------------------------------------------------------------------------------------------------------------------

VARIABLE: AS

LOC        N          MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES         T        DF   PROB > |T|

WS03      13    0.00976923     0.01330510     0.00369017     0.00100000     0.05000000   UNEQUAL     -0.2036      11.1       0.8424
WS06       6    0.01100000     0.01173030     0.00478888     0.00100000     0.03000000   EQUAL       -0.1939      17.0       0.8486

FOR HO: VARIANCES ARE EQUAL, F'=     1.29 WITH 12 AND 5 DF      PROB > F'= 0.8309
```

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                              S T A T I S T I C A L   A N A L Y S I S   S Y S T E M           10:19 WEDNESDAY, FEBRUARY 28, 1979

                                                   TTEST PROCEDURE

VARIABLE: MOLY

LOC        N          MEAN          STD DEV        STD ERROR        MINIMUM          MAXIMUM      VARIANCES        T        DF   PROB > |T|

WS03       8    0.02500000       0.01603567       0.00566947      0.01000000       0.05000000      UNEQUAL      0.5966      12.7       0.5613
WS06       7    0.02000000       0.01632993       0.00617213      0.00000000       0.05000000      EQUAL        0.5974      13.0       0.5605

FOR H0: VARIANCES ARE EQUAL, F'=    1.04 WITH 6 AND 7 DF      PROB > F'= 0.9481
------------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: SO4

LOC        N          MEAN          STD DEV        STD ERROR        MINIMUM          MAXIMUM      VARIANCES        T        DF   PROB > |T|

WS03      13  386.84615385      59.01108110      16.36672913    218.00000000     435.00000000      UNEQUAL      1.6506      16.6       0.1176
WS06       7  356.71428571      21.39091930       8.08500754    320.00000000     387.00000000      EQUAL        1.2922      18.0       0.2126

FOR H0: VARIANCES ARE EQUAL, F'=    7.61 WITH 12 AND 6 DF      PROB > F'= 0.0207
------------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: NA

LOC        N          MEAN          STD DEV        STD ERROR        MINIMUM          MAXIMUM      VARIANCES        T        DF   PROB > |T|

WS03      13  138.53846154      19.40195602       5.38113441    120.00000000     200.00000000      UNEQUAL     -0.5160      18.0       0.6122
WS06       7  142.00000000      10.59874206       4.00594796    128.00000000     160.00000000      EQUAL       -0.4348      18.0       0.6689

FOR H0: VARIANCES ARE EQUAL, F'=    3.35 WITH 12 AND 6 DF      PROB > F'= 0.1480
------------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: NH3

LOC        N          MEAN          STD DEV        STD ERROR        MINIMUM          MAXIMUM      VARIANCES        T        DF   PROB > |T|

WS03      12    0.15666667       0.14137849       0.04081246      0.01000000       0.40000000      UNEQUAL     -0.0091       4.6       0.9932
WS06       4    0.15750000       0.16500000       0.08250000      0.03000000       0.40000000      EQUAL       -0.0098      14.0       0.9923

FOR H0: VARIANCES ARE EQUAL, F'=    1.36 WITH 3 AND 11 DF      PROB > F'= 0.6104
```

```
                         S T A T I S T I C A L   A N A L Y S I S   S Y S T E M                    13:39 WEDNESDAY, FEBRUARY 28, 1979

                                                   TTEST PROCEDURE
VARIABLE: SPECCOND

LOC         N            MEAN          STD DEV        STD ERROR          MINIMUM          MAXIMUM    VARIANCES          T         DF   PROB > |T|

WS03       12   1355.33333333     109.48834171      31.60656178    1200.00000000    1559.00000000    UNEQUAL      -0.1467       12.3       0.8858
WS06        7   1363.14285714     113.38346230      42.85492058    1200.00000000    1562.00000000    EQUAL        -0.1481       17.0       0.8840

FOR H0: VARIANCES ARE EQUAL, F'=     1.07 WITH 6 AND 11 DF      PROB > F'= 0.8680
-----------------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: TDS

LOC         N            MEAN          STD DEV        STD ERROR          MINIMUM          MAXIMUM    VARIANCES          T         DF   PROB > |T|

WS03        9    984.66666667      76.40680598      25.46893533     846.00000000    1130.00000000    UNEQUAL       1.8433       10.6       0.0934 *
WS06        4    932.50000000      24.67792536      12.33896268     900.00000000     960.00000000    EQUAL         1.3070       11.0       0.2179

FOR H0: VARIANCES ARE EQUAL, F'=     9.59 WITH 8 AND 3 DF      PROB > F'= 0.0895
```

```
                         S T A T I S T I C A L   A N A L Y S I S   S Y S T E M    8:57 TUESDAY, FEBRUARY 27, 1979   1
                                                  TTEST PROCEDURE

VARIABLE: PH

LOC       N          MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES        T        DF  PROB > |T|

WS03     13    8.23076923     0.27804261     0.07711514     7.60000000     8.50000000   UNEQUAL     0.6776      12.5      0.5104
WS07      7    8.14285714     0.27602622     0.10432811     7.70000000     8.40000000   EQUAL       0.6761      18.0      0.5076

FOR H0: VARIANCES ARE EQUAL, F'=    1.01 WITH 12 AND 6 DF     PROB > F'= 1.0000
-------------------------------------------------------------------------------------------------------------------------------
VARIABLE: B

LOC       N          MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES        T        DF  PROB > |T|

WS03      9    0.19777778     0.35912316     0.11970772     0.00000000     1.10000000   UNEQUAL    -0.3687       9.5      0.7205
WS07      7    0.29000000     0.58106225     0.21962089     0.02000000     1.60000000   EQUAL      -0.3916      14.0      0.7013

FOR H0: VARIANCES ARE EQUAL, F'=    2.62 WITH 6 AND 8 DF     PROB > F'= 0.2085
-------------------------------------------------------------------------------------------------------------------------------
VARIABLE: F

LOC       N          MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES        T        DF  PROB > |T|

WS03     13    0.25384615     0.15063966     0.04177992     0.10000000     0.70000000   UNEQUAL    -1.7690       6.8      0.1215
WS07      7    0.54857143     0.42670945     0.16128101     0.30000000     1.50000000   EQUAL      -2.2831      18.0      0.0348

FOR H0: VARIANCES ARE EQUAL, F'=    8.02 WITH 6 AND 12 DF     PROB > F'= 0.0024
-------------------------------------------------------------------------------------------------------------------------------
VARIABLE: AS

LOC       N          MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES        T        DF  PROB > |T|

WS03     13    0.00976923     0.01330510     0.00369017     0.00100000     0.05000000   UNEQUAL     0.5856      18.0      0.5654
WS07      7    0.00714286     0.00674360     0.00254884     0.00100000     0.02000000   EQUAL       0.4855      18.0      0.6332

FOR H0: VARIANCES ARE EQUAL, F'=    3.89 WITH 12 AND 6 DF     PROB > F'= 0.1063
```

```
                         S T A T I S T I C A L   A N A L Y S I S   S Y S T E M     10:18 WEDNESDAY, FEBRUARY 28, 1979  1

                                                    TTEST PROCEDURE

VARIABLE: MOLY

LOC        N          MEAN          STD DEV      STD ERROR        MINIMUM         MAXIMUM    VARIANCES        T        DF   PROB > |T|

WS03       8    0.02500000       0.01603567     0.00566947     0.01000000      0.05000000    UNEQUAL     1.7811       9.3       0.1076
WS07       5    0.01400000       0.00547723     0.00244949     0.01000000      0.02000000    EQUAL       1.4605      11.0       0.1721

FOR H0: VARIANCES ARE EQUAL, F'=    8.57 WITH 7 AND 4 DF      PROB > F'= 0.0553
------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: SO4

LOC        N          MEAN          STD DEV      STD ERROR        MINIMUM         MAXIMUM    VARIANCES        T        DF   PROB > |T|

WS03      13  386.84615385      59.01108110    16.36672913   218.00000000    435.00000000    UNEQUAL     1.6732       9.6       0.1266
WS07       7  329.14285714      80.31278141    30.35537810   156.00000000    381.00000000    EQUAL       1.8407      18.0       0.0822

FOR H0: VARIANCES ARE EQUAL, F'=    1.85 WITH 6 AND 12 DF      PROB > F'= 0.3423
------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: NA

LOC        N          MEAN          STD DEV      STD ERROR        MINIMUM         MAXIMUM    VARIANCES        T        DF   PROB > |T|

WS03      13  138.53846154      19.40195602     5.38113441   120.00000000    200.00000000    UNEQUAL     0.6878      17.4       0.5007
WS07       7  134.28571429       8.05634917     3.04501377   127.00000000    150.00000000    EQUAL       0.5494      18.0       0.5895

FOR H0: VARIANCES ARE EQUAL, F'=    5.80 WITH 12 AND 6 DF      PROB > F'= 0.0413
------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: NH3

LOC        N          MEAN          STD DEV      STD ERROR        MINIMUM         MAXIMUM    VARIANCES        T        DF   PROB > |T|

WS03      12    0.15666667       0.14137849     0.04081246     0.01000000      0.40000000    UNEQUAL    -1.0312       4.3       0.3573
WS07       5    0.37600000       0.46677618     0.20874865     0.10000000      1.20000000    EQUAL      -1.5276      15.0       0.1474

FOR H0: VARIANCES ARE EQUAL, F'=   10.90 WITH 4 AND 11 DF      PROB > F'= 0.0016
```

```
                          S T A T I S T I C A L   A N A L Y S I S   S Y S T E M                                        1
                                                                                              13:38 WEDNESDAY, FEBRUARY 28, 1979

                                                         TTEST PROCEDURE

VARIABLE: SPECCOND

LOC        N            MEAN          STD DEV        STD ERROR         MINIMUM         MAXIMUM   VARIANCES          T        DF   PROB > |T|

WS03      12   1355.33333333   109.48834171    31.60656178   1200.00000000   1559.00000000   UNEQUAL       0.1980      11.1       0.8466
WS07       6   1345.16666667    99.09675407    40.45608044   1250.00000000   1521.00000000   EQUAL         0.1912      16.0       0.8508

FOR H0: VARIANCES ARE EQUAL, F'=     1.22 WITH 11 AND 5 DF      PROB > F'= 0.8786
---------------------------------------------------------------------------------------------------------------------------------------------
VARIABLE: TDS

LOC        N            MEAN          STD DEV        STD ERROR         MINIMUM         MAXIMUM   VARIANCES          T        DF   PROB > |T|

WS03       9    984.66666667    76.40680598    25.46893533    846.00000000   1130.00000000   UNEQUAL       0.0810       5.4       0.9384
WS07       4    980.75000000    82.22479350    41.11239675    921.00000000   1100.00000000   EQUAL         0.0835      11.0       0.9349

FOR H0: VARIANCES ARE EQUAL, F'=     1.16 WITH 3 AND 8 DF      PROB > F'= 0.7675
```

```
                               S T A T I S T I C A L   A N A L Y S I S   S Y S T E M    9:01 TUESDAY, FEBRUARY 27, 1979    1
                                                    TTEST PROCEDURE
VARIABLE: PH
LOC         N         MEAN       STD DEV     STD ERROR        MINIMUM        MAXIMUM   VARIANCES          T       DF  PROB > |T|

WS06        7   7.98571429    0.39761192    0.15028318     7.30000000     8.40000000   UNEQUAL      -0.8590     10.7      0.4092
WS07        7   8.14285714    0.27602622    0.10432811     7.70000000     8.40000000   EQUAL        -0.8590     12.0      0.4072

FOR H0: VARIANCES ARE EQUAL, F'=     2.07 WITH 6 AND 6 DF     PROB > F'= 0.3960
------------------------------------------------------------------------------------------------------------------------------
VARIABLE: B
LOC         N         MEAN       STD DEV     STD ERROR        MINIMUM        MAXIMUM   VARIANCES          T       DF  PROB > |T|

WS06        7   0.43857143    0.63964648    0.24176364     0.04000000     1.60000000   UNEQUAL       0.4549     11.9      0.6574
WS07        7   0.29000000    0.58106225    0.21962089     0.02000000     1.60000000   EQUAL         0.4549     12.0      0.6573

FOR H0: VARIANCES ARE EQUAL, F'=     1.21 WITH 6 AND 6 DF     PROB > F'= 0.8215
------------------------------------------------------------------------------------------------------------------------------
VARIABLE: F
LOC         N         MEAN       STD DEV     STD ERROR        MINIMUM        MAXIMUM   VARIANCES          T       DF  PROB > |T|

WS06        7   0.71428571    0.61492160    0.23241852     0.40000000     2.10000000   UNEQUAL       0.5858     10.7      0.5702
WS07        7   0.54857143    0.42670945    0.16128101     0.30000000     1.50000000   EQUAL         0.5858     12.0      0.5689

FOR H0: VARIANCES ARE EQUAL, F'=     2.08 WITH 6 AND 6 DF     PROB > F'= 0.3954
------------------------------------------------------------------------------------------------------------------------------
VARIABLE: AS
LOC         N         MEAN       STD DEV     STD ERROR        MINIMUM        MAXIMUM   VARIANCES          T       DF  PROB > |T|

WS06        6   0.01100000    0.01173030    0.00478888     0.00100000     0.03000000   UNEQUAL       0.7110      7.7      0.4981
WS07        7   0.00714286    0.00674360    0.00254884     0.00100000     0.02000000   EQUAL         0.7418     11.0      0.4738

FOR H0: VARIANCES ARE EQUAL, F'=     3.03 WITH 5 AND 6 DF     PROB > F'= 0.2102
```

```
                            S T A T I S T I C A L   A N A L Y S I S   S Y S T E M       10:16 WEDNESDAY, FEBRUARY 28, 1979

                                                TTEST PROCEDURE

VARIABLE: MOLY

LOC        N          MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES        T       DF   PROB > |T|

WS06       7    0.02000000     0.01632993     0.00617213     0.00000000     0.05000000   UNEQUAL     0.9036      7.8       0.3935
WS07       5    0.01400000     0.00547723     0.00244949     0.01000000     0.02000000   EQUAL       0.7813     10.0       0.4527

FOR H0: VARIANCES ARE EQUAL, F'=     8.89 WITH 6 AND 4 DF     PROB > F'= 0.0531
----------------------------------------------------------------------------------------------------------------------------
VARIABLE: SO4

LOC        N          MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES        T       DF   PROB > |T|

WS06       7  356.71428571    21.39091930     8.08500754   320.00000000   387.00000000   UNEQUAL     0.8777      6.8       0.4099
WS07       7  329.14285714    80.31278141    30.35537810   156.00000000   381.00000000   EQUAL       0.8777     12.0       0.3973

FOR H0: VARIANCES ARE EQUAL, F'=    14.10 WITH 6 AND 6 DF     PROB > F'= 0.0053
----------------------------------------------------------------------------------------------------------------------------
VARIABLE: NA

LOC        N          MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES        T       DF   PROB > |T|

WS06       7  142.00000000    10.59874206     4.00594796   128.00000000   160.00000000   UNEQUAL     1.5331     11.2       0.1530
WS07       7  134.28571429     8.05634917     3.04501377   127.00000000   150.00000000   EQUAL       1.5331     12.0       0.1512

FOR H0: VARIANCES ARE EQUAL, F'=     1.73 WITH 6 AND 6 DF     PROB > F'= 0.5217
----------------------------------------------------------------------------------------------------------------------------
VARIABLE: NH3

LOC        N          MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES        T       DF   PROB > |T|

WS06       4    0.15750000     0.16500000     0.08250000     0.03000000     0.40000000   UNEQUAL    -0.9734      5.2       0.3738
WS07       5    0.37600000     0.46677618     0.20874865     0.10000000     1.20000000   EQUAL      -0.8827      7.0       0.4067

FOR H0: VARIANCES ARE EQUAL, F'=     8.00 WITH 4 AND 3 DF     PROB > F'= 0.1190
```

```
                                    S T A T I S T I C A L   A N A L Y S I S   S Y S T E M          13:36 WEDNESDAY, FEBRUARY 28, 1979   1

                                                         TTEST PROCEDURE

VARIABLE: SPECCOND

LOC        N            MEAN          STD DEV        STD ERROR         MINIMUM          MAXIMUM    VARIANCES          T       DF   PROB > |T|

WS06       7   1363.14285714     113.38346230      42.85492058   1200.00000000    1562.00000000    UNEQUAL       0.3050     11.0       0.7661
WS07       6   1345.16666667      99.09675407      40.45608044   1250.00000000    1521.00000000    EQUAL         0.3016     11.0       0.7686

FOR H0: VARIANCES ARE EQUAL, F'=    1.31 WITH 6 AND 5 DF     PROB > F'= 0.7852
------------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: TDS

LOC        N            MEAN          STD DEV        STD ERROR         MINIMUM          MAXIMUM    VARIANCES          T       DF   PROB > |T|

WS06       4    932.50000000      24.67792536      12.33896268    900.00000000     960.00000000    UNEQUAL      -1.1241      3.5       0.3327
WS07       4    980.75000000      82.22479350      41.11239675    921.00000000    1100.00000000    EQUAL        -1.1241      6.0       0.3039

FOR H0: VARIANCES ARE EQUAL, F'=   11.10 WITH 3 AND 3 DF     PROB > F'= 0.0786
```

```
                               S T A T I S T I C A L   A N A L Y S I S   S Y S T E M    8:57 TUESDAY, FEBRUARY 27, 1979    1
                                                  TTEST PROCEDURE

VARIABLE: PH

LOC        N          MEAN         STD DEV       STD ERROR        MINIMUM         MAXIMUM    VARIANCES        T        DF   PROB > |T|

WS01       5    8.42000000      0.47644517      0.21307276     7.90000000      9.20000000    UNEQUAL     1.1682       5.9       0.2877
WS07       7    8.14285714      0.27602622      0.10432811     7.70000000      8.40000000    EQUAL       1.2810      10.0       0.2291

FOR HO: VARIANCES ARE EQUAL, F'=     2.98 WITH 4 AND 6 DF      PROB > F'= 0.2250
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VARIABLE: B

LOC        N          MEAN         STD DEV       STD ERROR        MINIMUM         MAXIMUM    VARIANCES        T        DF   PROB > |T|

WS01       4    0.37250000      0.68504866      0.34252433     0.02000000      1.40000000    UNEQUAL     0.2028       5.5       0.8467
WS07       7    0.29000000      0.58106225      0.21962089     0.02000000      1.60000000    EQUAL       0.2131       9.0       0.8360

FOR HO: VARIANCES ARE EQUAL, F'=     1.39 WITH 3 AND 6 DF      PROB > F'= 0.6675
---------------------------------------------------------------------------------------------------------------------------------

VARIABLE: F

LOC        N          MEAN         STD DEV       STD ERROR        MINIMUM         MAXIMUM    VARIANCES        T        DF   PROB > |T|

WS01       5    0.36000000      0.30495901      0.13638182     0.20000000      0.90000000    UNEQUAL    -0.8928      10.0       0.3930
WS07       7    0.54857143      0.42670945      0.16128101     0.30000000      1.50000000    EQUAL      -0.8415      10.0       0.4197

FOR HO: VARIANCES ARE EQUAL, F'=     1.96 WITH 6 AND 4 DF      PROB > F'= 0.5370
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VARIABLE: AS

LOC        N          MEAN         STD DEV       STD ERROR        MINIMUM         MAXIMUM    VARIANCES        T        DF   PROB > |T|

WS01       5    0.00700000      0.00815475      0.00364692     0.00100000      0.02000000    UNEQUAL    -0.0321       7.6       0.9752
WS07       7    0.00714286      0.00674360      0.00254884     0.00100000      0.02000000    EQUAL      -0.0332      10.0       0.9741

FOR HO: VARIANCES ARE EQUAL, F'=     1.46 WITH 4 AND 6 DF      PROB > F'= 0.6442
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                          S T A T I S T I C A L   A N A L Y S I S   S Y S T E M                                       1
                                                                                         10:25 WEDNESDAY, FEBRUARY 28, 1979
                                                 TTEST PROCEDURE

VARIABLE: MOLY

LOC        N          MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES        T       DF  PROB > |T|

WS01       3    0.02333333     0.01527525     0.00881917     0.01000000     0.04000000   UNEQUAL     1.0197      2.3      0.4050
WS07       5    0.01400000     0.00547723     0.00244949     0.01000000     0.02000000   EQUAL       1.2925      6.0      0.2437

FOR H0: VARIANCES ARE EQUAL, F'=    7.78 WITH 2 AND 4 DF     PROB > F'= 0.0837
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VARIABLE: SO4

LOC        N          MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES        T       DF  PROB > |T|

WS01       5  378.20000000    59.92244988    26.79813426   280.00000000   440.00000000   UNEQUAL     1.2115      9.9      0.2537
WS07       7  329.14285714    80.31278141    30.35537810   156.00000000   381.00000000   EQUAL       1.1501     10.0      0.2769

FOR H0: VARIANCES ARE EQUAL, F'=    1.80 WITH 6 AND 4 DF     PROB > F'= 0.5941
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VARIABLE: NA

LOC        N          MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES        T       DF  PROB > |T|

WS01       5  140.00000000    33.86000591    15.14265499   122.00000000   200.00000000   UNEQUAL     0.3700      4.3      0.7290
WS07       7  134.28571429     8.05634917     3.04501377   127.00000000   150.00000000   EQUAL       0.4375     10.0      0.6710

FOR H0: VARIANCES ARE EQUAL, F'=   17.66 WITH 4 AND 6 DF     PROB > F'= 0.0036
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VARIABLE: NH3

LOC        N          MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES        T       DF  PROB > |T|

WS01       3    0.14666667     0.08082904     0.04666667     0.10000000     0.24000000   UNEQUAL    -1.0721      4.4      0.3396
WS07       5    0.37600000     0.46677618     0.20874865     0.10000000     1.20000000   EQUAL      -0.8178      6.0      0.4447

FOR H0: VARIANCES ARE EQUAL, F'=   33.35 WITH 4 AND 2 DF     PROB > F'= 0.0586
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                                 S T A T I S T I C A L   A N A L Y S I S   S Y S T E M        13:35 WEDNESDAY, FEBRUARY 28, 1979

                                                        TTEST PROCEDURE

VARIABLE: SPECCOND

LOC      N           MEAN        STD DEV       STD ERROR        MINIMUM         MAXIMUM    VARIANCES          T        DF   PROB > |T|

WS01     5  1324.20000000   118.22943796     52.87381204  1200.00000000   1521.00000000    UNEQUAL      -0.3149       7.9       0.7610
WS07     6  1345.16666667    99.09675407     40.45608044  1250.00000000   1521.00000000    EQUAL        -0.3205       9.0       0.7559

FOR H0: VARIANCES ARE EQUAL, F'=    1.42 WITH 4 AND 5 DF      PROB > F'= 0.6969
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VARIABLE: TDS

LOC      N           MEAN        STD DEV       STD ERROR        MINIMUM         MAXIMUM    VARIANCES          T        DF   PROB > |T|

WS01     4   946.25000000   111.76276959     55.88138480   839.00000000   1100.00000000    UNEQUAL      -0.4973       5.5       0.6383
WS07     4   980.75000000    82.22479350     41.11239675   921.00000000   1100.00000000    EQUAL        -0.4973       6.0       0.6367

FOR H0: VARIANCES ARE EQUAL, F'=    1.85 WITH 3 AND 3 DF      PROB > F'= 0.6267
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                                   S T A T I S T I C A L   A N A L Y S I S   S Y S T E M    8:55 TUESDAY, FEBRUARY 27, 1979   1
                                                        TTEST PROCEDURE
VARIABLE: PH

LOC        N          MEAN          STD DEV       STD ERROR        MINIMUM          MAXIMUM     VARIANCES        T        DF   PROB > |T|

WS01       5    8.42000000       0.47644517      0.21307276     7.90000000       9.20000000     UNEQUAL     0.8351       5.1       0.4412
WS03      13    8.23076923       0.27804261      0.07711514     7.60000000       8.50000000     EQUAL       1.0616      16.0       0.3042

FOR HO: VARIANCES ARE EQUAL, F'=     2.94 WITH 4 AND 12 DF     PROB > F'= 0.1322
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VARIABLE: B

LOC        N          MEAN          STD DEV       STD ERROR        MINIMUM          MAXIMUM     VARIANCES        T        DF   PROB > |T|

WS01       4    0.37250000       0.68504866      0.34252433     0.02000000       1.40000000     UNEQUAL     0.4815       3.8       0.6572
WS03       9    0.19777778       0.35912316      0.11970772     0.00000000       1.10000000     EQUAL       0.6174      11.0       0.5495

FOR HO: VARIANCES ARE EQUAL, F'=     3.64 WITH 3 AND 8 DF     PROB > F'= 0.1279
------------------------------------------------------------------------------------------------------------------------------------
VARIABLE: F

LOC        N          MEAN          STD DEV       STD ERROR        MINIMUM          MAXIMUM     VARIANCES        T        DF   PROB > |T|

WS01       5    0.36000000       0.30495901      0.13638182     0.20000000       0.90000000     UNEQUAL     0.7442       4.8       0.4920
WS03      13    0.25384615       0.15063966      0.04177992     0.10000000       0.70000000     EQUAL       1.0052      16.0       0.3297

FOR HO: VARIANCES ARE EQUAL, F'=     4.10 WITH 4 AND 12 DF     PROB > F'= 0.0509
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VARIABLE: AS

LOC        N          MEAN          STD DEV       STD ERROR        MINIMUM          MAXIMUM     VARIANCES        T        DF   PROB > |T|

WS01       5    0.00700000       0.00815475      0.00364692     0.00100000       0.02000000     UNEQUAL    -0.5338      12.1       0.6032
WS03      13    0.00976923       0.01330510      0.00369017     0.00100000       0.05000000     EQUAL      -0.4305      16.0       0.6725

FOR HO: VARIANCES ARE EQUAL, F'=     2.66 WITH 12 AND 4 DF     PROB > F'= 0.3567
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                             S T A T I S T I C A L   A N A L Y S I S   S Y S T E M          10:28 WEDNESDAY, FEBRUARY 28, 1979

                                                     TTEST PROCEDURE

VARIABLE: MOLY

LOC          N          MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES        T       DF  PROB > |T|

WS01         3    0.02333333     0.01527525     0.00881917     0.01000000     0.04000000   UNEQUAL    -0.1590      3.8      0.8819
WS03         8    0.02500000     0.01603567     0.00566947     0.01000000     0.05000000   EQUAL      -0.1551      9.0      0.8801

FOR H0: VARIANCES ARE EQUAL, F'=    1.10 WITH 7 AND 2 DF     PROB > F'= 1.0000
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VARIABLE: SO4

LOC          N          MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES        T       DF  PROB > |T|

WS01         5  378.20000000    59.92244988    26.79813426   280.00000000   440.00000000   UNEQUAL    -0.2753      7.2      0.7908
WS03        13  386.84615385    59.01108110    16.36672913   218.00000000   435.00000000   EQUAL      -0.2773     16.0      0.7851

FOR H0: VARIANCES ARE EQUAL, F'=    1.03 WITH 4 AND 12 DF     PROB > F'= 0.8613
---------------------------------------------------------------------------------------------------------------------------------

VARIABLE: NA

LOC          N          MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES        T       DF  PROB > |T|

WS01         5  140.00000000    33.86000591    15.14265499   122.00000000   200.00000000   UNEQUAL     0.0909      5.0      0.9310
WS03        13  138.53846154    19.40195602     5.38113441   120.00000000   200.00000000   EQUAL       0.1164     16.0      0.9088

FOR H0: VARIANCES ARE EQUAL, F'=    3.05 WITH 4 AND 12 DF     PROB > F'= 0.1201
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VARIABLE: NH3

LOC          N          MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES        T       DF  PROB > |T|

WS01         3    0.14666667     0.08082904     0.04666667     0.10000000     0.24000000   UNEQUAL    -0.1613      5.6      0.8775
WS03        12    0.15666667     0.14137849     0.04081246     0.01000000     0.40000000   EQUAL      -0.1157     13.0      0.9096

FOR H0: VARIANCES ARE EQUAL, F'=    3.06 WITH 11 AND 2 DF     PROB > F'= 0.5441
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                                        S T A T I S T I C A L   A N A L Y S I S   S Y S T E M                                        1
                                                                                                  13:27 WEDNESDAY, FEBRUARY 28, 1979
                                                          TTEST PROCEDURE

VARIABLE: SPECCOND

LOC       N          MEAN          STD DEV       STD ERROR        MINIMUM          MAXIMUM    VARIANCES          T        DF   PROB > |T|

WS01      5  1324.20000000    118.22943796     52.87381204  1200.00000000    1521.00000000    UNEQUAL      -0.5054       7.0       0.6287
WS03     12  1355.33333333    109.48834171     31.60656178  1200.00000000    1559.00000000    EQUAL        -0.5228      15.0       0.6088

FOR H0: VARIANCES ARE EQUAL, F'=    1.17 WITH 4 AND 11 DF      PROB > F'= 0.7550
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VARIABLE: TDS

LOC       N          MEAN          STD DEV       STD ERROR        MINIMUM          MAXIMUM    VARIANCES          T        DF   PROB > |T|

WS01      4   946.25000000    111.76276959     55.88138480   839.00000000    1100.00000000    UNEQUAL      -0.6256       4.3       0.5635
WS03      9   984.66666667     76.40680598     25.46893533   846.00000000    1130.00000000    EQUAL        -0.7308      11.0       0.4802

FOR H0: VARIANCES ARE EQUAL, F'=    2.14 WITH 3 AND 8 DF       PROB > F'= 0.3467
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                          S T A T I S T I C A L   A N A L Y S I S   S Y S T E M    8:56 TUESDAY, FEBRUARY 27, 1979    1
                                              TTEST PROCEDURE

VARIABLE: PH

LOC       N          MEAN         STD DEV       STD ERROR         MINIMUM          MAXIMUM    VARIANCES        T        DF   PROB > |T|

WS01      5    8.42000000      0.47644517      0.21307276      7.90000000       9.20000000    UNEQUAL     1.6656       7.7       0.1360
WS06      7    7.98571429      0.39761192      0.15028318      7.30000000       8.40000000    EQUAL       1.7213      10.0       0.1159

FOR H0: VARIANCES ARE EQUAL, F'=    1.44 WITH 4 AND 6 DF      PROB > F'= 0.6581
-----------------------------------------------------------------------------------------------------------------------------------
VARIABLE: B

LOC       N          MEAN         STD DEV       STD ERROR         MINIMUM          MAXIMUM    VARIANCES        T        DF   PROB > |T|

WS01      4    0.37250000      0.68504866      0.34252433      0.02000000       1.40000000    UNEQUAL    -0.1576       6.0       0.8800
WS06      7    0.43857143      0.63964648      0.24176364      0.04000000       1.60000000    EQUAL      -0.1609       9.0       0.8757

FOR H0: VARIANCES ARE EQUAL, F'=    1.15 WITH 3 AND 6 DF      PROB > F'= 0.8071
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VARIABLE: F

LOC       N          MEAN         STD DEV       STD ERROR         MINIMUM          MAXIMUM    VARIANCES        T        DF   PROB > |T|

WS01      5    0.36000000      0.30495901      0.13638182      0.20000000       0.90000000    UNEQUAL    -1.3147       9.2       0.2205
WS06      7    0.71428571      0.61492160      0.23241852      0.40000000       2.10000000    EQUAL      -1.1774      10.0       0.2663

FOR H0: VARIANCES ARE EQUAL, F'=    4.07 WITH 6 AND 4 DF      PROB > F'= 0.1958
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VARIABLE: AS

LOC       N          MEAN         STD DEV       STD ERROR         MINIMUM          MAXIMUM    VARIANCES        T        DF   PROB > |T|

WS01      5    0.00700000      0.00815475      0.00364692      0.00100000       0.02000000    UNEQUAL    -0.6645       8.8       0.5235
WS06      6    0.01100000      0.01173030      0.00478888      0.00100000       0.03000000    EQUAL      -0.6416       9.0       0.5371

FOR H0: VARIANCES ARE EQUAL, F'=    2.07 WITH 5 AND 4 DF      PROB > F'= 0.5009
```

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                              S T A T I S T I C A L   A N A L Y S I S   S Y S T E M          10:23 WEDNESDAY, FEBRUARY 28, 1979

                                                       TTEST PROCEDURE

VARIABLE: MOLY

LOC        N          MEAN          STD DEV       STD ERROR         MINIMUM         MAXIMUM    VARIANCES          T       DF   PROB > |T|

WS01       3    0.02333333       0.01527525      0.00881917      0.01000000      0.04000000    UNEQUAL       0.3097      4.1       0.7720
WS06       7    0.02000000       0.01632993      0.00617213      0.00000000      0.05000000    EQUAL         0.3005      8.0       0.7714

FOR H0: VARIANCES ARE EQUAL, F'=    1.14 WITH 6 AND 2 DF      PROB > F'= 1.0000
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VARIABLE: SO4

LOC        N          MEAN          STD DEV       STD ERROR         MINIMUM         MAXIMUM    VARIANCES          T       DF   PROB > |T|

WS01       5  378.20000000      59.92244988     26.79813426    280.00000000    440.00000000    UNEQUAL       0.7676      4.7       0.4796
WS06       7  356.71428571      21.39091930      8.08500754    320.00000000    387.00000000    EQUAL         0.8871     10.0       0.3958

FOR H0: VARIANCES ARE EQUAL, F'=    7.85 WITH 4 AND 6 DF      PROB > F'= 0.0291
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VARIABLE: NA

LOC        N          MEAN          STD DEV       STD ERROR         MINIMUM         MAXIMUM    VARIANCES          T       DF   PROB > |T|

WS01       5  140.00000000      33.86000591     15.14265499    122.00000000    200.00000000    UNEQUAL      -0.1277      4.6       0.9039
WS06       7  142.00000000      10.59874206      4.00594796    128.00000000    160.00000000    EQUAL        -0.1489     10.0       0.8846

FOR H0: VARIANCES ARE EQUAL, F'=   10.21 WITH 4 AND 6 DF      PROB > F'= 0.0152
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VARIABLE: NH3

LOC        N          MEAN          STD DEV       STD ERROR         MINIMUM         MAXIMUM    VARIANCES          T       DF   PROB > |T|

WS01       3    0.14666667       0.08082904      0.04666667      0.10000000      0.24000000    UNEQUAL      -0.1143      4.5       0.9139
WS06       4    0.15750000       0.16500000      0.08250000      0.03000000      0.40000000    EQUAL        -0.1030      5.0       0.9219

FOR H0: VARIANCES ARE EQUAL, F'=    4.17 WITH 3 AND 2 DF      PROB > F'= 0.3991
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                              S T A T I S T I C A L   A N A L Y S I S   S Y S T E M                13:29 WEDNESDAY, FEBRUARY 28, 1979

                                                    TTEST PROCEDURE

VARIABLE: SPECCOND

LOC         N            MEAN          STD DEV       STD ERROR         MINIMUM         MAXIMUM    VARIANCES         T       DF  PROB > |T|

WS01        5   1324.20000000     118.22943796     52.87381204   1200.00000000   1521.00000000    UNEQUAL     -0.5722      8.5      0.5820
WS06        7   1363.14285714     113.38346230     42.85492058   1200.00000000   1562.00000000    EQUAL       -0.5766     10.0      0.5770

FOR H0: VARIANCES ARE EQUAL, F'=     1.09 WITH 4 AND 6 DF      PROB > F'= 0.8811
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VARIABLE: TDS

LOC         N            MEAN          STD DEV       STD ERROR         MINIMUM         MAXIMUM    VARIANCES         T       DF  PROB > |T|

WS01        4    946.25000000     111.76276959     55.88138480    839.00000000   1100.00000000    UNEQUAL      0.2403      3.3      0.8245
WS06        4    932.50000000      24.67792536     12.33896268    900.00000000    960.00000000    EQUAL        0.2403      6.0      0.8181

FOR H0: VARIANCES ARE EQUAL, F'=    20.51 WITH 3 AND 3 DF      PROB > F'= 0.0336
```

APPENDIX A5.3.1

This Appendix is in three parts:

- A5.3.1A - Summary Tables for Regression and Comparative Analyses
- A5.3.1B - Linear Regression Data for Alluvial Wells
- A5.3.1C - T-TEST Procedure Results for Alluvial Wells

APPENDIX A5.3.1A

Summary Tables for Regression and Comparative Analyses

List of Tables Appearing in Appendix A5.3.1A

Table A5.3.1A-1

LINEAR REGRESSION OF WATER QUALITY PARAMETERS VS TIME

Alluvial Well WA01

PARAMETERS	NO. OF OBS.	ESTIMATE OF SLOPE	L L* (95% Conf)	U L* (95% Conf)	T FOR H_0: SLOPE = 0	IS SLOPE SIGNIFICANTLY DIFFERENT FROM ZERO? (95% Conf)
pH	13	-0.1819	-0.428	0.066	-1.60	N
B	8	-0.111	-0.223	0.001	-2.36	N
F	13	-0.417	-0.877	0.043	-1.98	N
As	11	0.00313	-0.00057	0.00683	1.88	N
SO_4	12	-92.8	-154.6	-31.0	-3.31	Y
Na	13	-8.73	-28.8	11.4	-0.95	N
NH_3	12	0.0596	-3.62	3.74	0.04	N
Mo	8	0.0116	-0.0072	0.0304	1.46	N

* Lower and Upper Limits of slope based on standard error of the estimate and the t-statistic for the no. of degrees of freedom.

Table A5.3.1A-2

LINEAR REGRESSION OF WATER QUALITY PARAMETERS VS TIME

Alluvial Well WA02

PARAMETERS	NO. OF OBS.	ESTIMATE OF SLOPE	L L* (95% Conf)	U L* (95% Conf)	T FOR H_o: SLOPE = 0	IS SLOPE SIGNIFICANTLY DIFFERENT FROM ZERO? (95% Conf)
pH	5	0.105	-0.947	1.157	0.28	N
B	4	-0.712	-2.151	0.727	-1.58	N
F	5	-1.351	-3.40	06.78	-1.85	N
As	4	-0.00392	-0.010	0.00219	-2.05	N
SO_4	5	-69.9	-208.0	68.0	-1.41	N
Na	5	-53.1	-117.0	10.8	-2.31	N
NH_3	5	-0.0917	-0.756	0.572	-0.38	N
Mo	3	0.00672	-0.0630	0.0764	0.41	N

* Lower and Upper Limits of slope based on standard error of the estimate and the t-statistic for the no. of degrees of freedom.

Table A5.3.1A-3

LINEAR REGRESSION OF WATER QUALITY PARAMETERS VS TIME

Alluvial Well WA03

PARAMETERS	NO. OF OBS.	ESTIMATE OF SLOPE	L L* (95% Conf)	U L* (95% Conf)	T FOR H_o: SLOPE = 0	IS SLOPE SIGNIFICANTLY DIFFERENT FROM ZERO? (95% Conf)
pH	11	-0.00688	-0.321	0.321	-0.05	N
B	6	-0.171	-0.392	0.05	-1.99	N
F	11	-0.381	-0.717	-0.045	-2.53	Y
As	9	0.00248	-0.0147	0.0197	0.33	N
SO_4	11	-0.889	-18.8	17.0	-0.11	N
Na	11	-29.9	-58.0	-1.78	-2.37	Y
NH_3	10	-0.0114	-0.102	0.0789	-0.29	N
Mo	5	0.00146	-0.00582	0.00874	0.56	N
Level	33	-0.2033	-0.5709	0.1643	--	Y

* Lower and Upper Limits of slope based on standard error of the estimate and the t-statistic for the no. of degrees of freedom.

Table A5.3.1A-4

LINEAR REGRESSION OF WATER QUALITY PARAMETERS VS TIME

Alluvial Well WA05

PARAMETERS	NO. OF OBS.	ESTIMATE OF SLOPE	L L* (95% Conf)	U L* (95% Conf)	T FOR H_o: SLOPE = 0	IS SLOPE SIGNIFICANTLY DIFFERENT FROM ZERO? (95% Conf)
pH	6	-0.0716	-0.370	0.226	-0.62	N
B	5	-0.273	-0.651	0.105	-2.01	N
F	6	-0.770	-2.59	1.05	-1.09	N
As	6	-0.00496	-0.0250	0.0150	-0.64	N
SO_4	6	-57.4	-136.6	21.8	1.86	N
Na	6	-25.9	-79.1	27.3	1.25	N
NH_3	5	-0.107	-0.604	0.390	-0.60	N
Mo	5	-0.000478	-0.0244	0.0234	-0.06	N
Level	33	-0.000409	-0.8580	0.8572	--	N

* Lower and Upper Limits of slope based on standard error of the estimate and the t-statistic for the no. of degrees of freedom.

Table A5.3.1A-5

LINEAR REGRESSION OF WATER QUALITY PARAMETERS VS TIME

Alluvial Well WA06

PARAMETERS	NO. OF OBS.	ESTIMATE OF SLOPE	L L* (95% Conf)	U L* (95% Conf)	T FOR H_0: SLOPE = 0	IS SLOPE SIGNIFICANTLY DIFFERENT FROM ZERO? (95% Conf)
pH	11	0.0609	-0.260	0.382	0.42	N
B	6	-0.390	-0.773	-0.007	-2.62	Y
F	11	-0.357	-0.698	-0.016	-2.34	Y
As	10	0.00320	-0.0117	0.0181	-0.49	N
SO_4	11	-41.9	-64.4	-19.4	-4.15	Y
Na	11	-32.1	-58.5	-5.70	-2.71	Y
NH_3	10	-0.0828	-0.268	0.102	-1.01	N
Mo	5	-0.0103	-0.0228	0.0022	-2.29	N
Level	33	-0.05	-5.4430	5.5430	--	N

* Lower and Upper Limits of slope based on standard error of the estimate and the t-statistic for the no. of degrees of freedom.

Table A5.3.1A-6

LINEAR REGRESSION OF WATER QUALITY PARAMETERS VS TIME

Alluvial Well WA07

PARAMETERS	NO. OF OBS.	ESTIMATE OF SLOPE	L L* (95% Conf)	U L* (95% Conf)	T FOR H_0: SLOPE = 0	IS SLOPE SIGNIFICANTLY DIFFERENT FROM ZERO? (95% Conf)
pH	12	-0.103	-0.210	0.0035	-2.12	N
B	7	-0.337	-0.661	-0.013	-2.55	Y
F	12	-0.361	-0.771	-0.011	-2.27	Y
As	11	0.00216	-0.0109	0.0153	0.37	N
SO_4	12	-31.6	-80.3	17.1	-1.43	N
Na	12	-52.7	-100.6	-4.8	-2.42	Y
NH_3	11	-1.05	-2.71	0.61	-1.41	N
Mo	6	0.00188	-0.0354	0.0392	0.13	N

* Lower and Upper Limits of slope based on standard error of the estimate and the t-statistic for the no. of degrees of freedom.

Table A5.3.1A-7

LINEAR REGRESSION OF WATER QUALITY PARAMETERS VS TIME

Alluvial Well WA08

PARAMETERS	NO. OF OBS.	ESTIMATE OF SLOPE	L L* (95% Conf)	U L* (95% Conf)	T FOR H_0: SLOPE = 0	IS SLOPE SIGNIFICANTLY DIFFERENT FROM ZERO? (95% Conf)
pH	8	-0.0923	-0.352	0.168	-0.84	N
B	7	-0.108	-0.229	0.013	-2.20	N
F	8	-0.0851	-0.206	0.0359	-1.66	N
As	8	0.00301	-0.00011	0.00613	-2.28	N
SO_4	8	4.27	-26.0	34.6	0.33	N
Na	8	-21.4	-58.5	15.7	-1.36	N
NH_3	7	0.369	-0.721	1.46	0.83	N
Mo	6	0.00699	-0.0133	0.0273	0.88	N
Level	33	-0.08	-3.7352	3.5752	--	N

* Lower and Upper Limits of slope based on standard error of the estimate and the t-statistic for the no. of degrees of freedom.

Table A5.3.1A-8

LINEAR REGRESSION OF WATER QUALITY PARAMETERS VS TIME

Alluvial Well WA09

PARAMETERS	NO. OF OBS.	ESTIMATE OF SLOPE	L L* (95% Conf)	U L* (95% Conf)	T FOR H_0: SLOPE = 0	IS SLOPE SIGNIFICANTLY DIFFERENT FROM ZERO? (95% Conf)
pH	8	-0.072	-0.323	0.179	-0.68	N
B	7	-0.0171	-0.318	0.284	-0.14	N
F	8	-0.0877	-0.1991	0.0243	-1.85	N
As	8	0.00284	-0.0004	0.00608	2.08	N
SO_4	8	-7.54	-69.5	54.4	-0.29	N
Na	8	-7.00	-18.3	4.34	-1.46	N
NH_3	7	-0.252	-0.918	0.414	-0.93	N
Mo	7	-0.00761	-0.0256	0.0104	-1.03	N

* Lower and Upper Limits of slope based on standard error of the estimate and the t-statistic for the no. of degrees of freedom.

Table A5.3.1A-9

LINEAR REGRESSION OF WATER QUALITY PARAMETERS VS TIME

Alluvial Well WA10

PARAMETERS	NO. OF OBS.	ESTIMATE OF SLOPE	L L* (95% Conf)	U L* (95% Conf)	T FOR H_o: SLOPE = 0	IS SLOPE SIGNIFICANTLY DIFFERENT FROM ZERO? (95% Conf)
pH	7	-0.154	-0.312	0.004	-2.38	N
B	6	-0.183	-0.407	0.041	-2.10	N
F	7	-0.0747	-0.228	0.0783	-1.19	N
As	7	0.00375	-0.00039	0.00789	2.22	N
SO_4	7	-19.6	-37.6	-1 6	-2.66	Y
Na	7	-7.92	-31.4	15.58	-0.82	N
NH_3	6	-0.0487	-0.268	0.170	-0.57	N
Mo	5	0.00533	0.00166	0.009	4.04	Y

* Lower and Upper Limits of slope based on standard error of the estimate and the t-statistic for the no. of degrees of freedom.

Table A5.3.1A-10

LINEAR REGRESSION OF WATER QUALITY PARAMETERS VS TIME

Alluvial Well WA11

PARAMETERS	NO. OF OBS.	ESTIMATE OF SLOPE	L L* (95% Conf)	U L* (95% Conf)	T FOR H_0: SLOPE = 0	IS SLOPE SIGNIFICANTLY DIFFERENT FROM ZERO? (95% Conf)
pH	8	-0.0811	-0.344	0.182	-0.73	N
B	7	-0.080	-0.237	0.077	-1.25	N
F	8	-0.0403	-0.0996	0.019	-1.61	N
As	8	0.00247	-0.00098	0.00592	1.69	N
SO_4	8	-10.7	-50.7	29.25	-0.63	N
Na	8	-3.91	-13.2	5.33	-1.00	N
NH_3	7	0.704	-0.205	1.61	1.90	N
Mo	5	-0.00651	-0.0530	0.0399	-0.39	N

* Lower and Upper Limits of slope based on standard error of the estimate and the t-statistic for the no. of degrees of freedom.

Table A5.3.1A-11

LINEAR REGRESSION OF WATER QUALITY PARAMETERS VS TIME

Alluvial Well WA12

PARAMETERS	NO. OF OBS.	ESTIMATE OF SLOPE	L L* (95% Conf)	U L* (95% Conf)	T FOR H_o: SLOPE = 0	IS SLOPE SIGNIFICANTLY DIFFERENT FROM ZERO? (95% Conf)
pH	8	-0.0654	-0.327	0.197	-0.59	N
B	7	-0.680	-1.81	0.45	-1.48	N
F	8	-0.209	-0.505	0.0865	-1.67	N
As	8	0.00219	-0.00131	0.00569	1.48	N
SO_4	8	-9.75	-29.4	9.85	-1.18	N
Na	8	-79.6	-195.0	36.0	-1.63	N
NH_3	7	-0.123	-0.382	0.136	-1.16	N
Mo	6	-0.00140	-0.0175	0.0147	-0.22	N

* Lower and Upper Limits of slope based on standard error of the estimate and the t-statistic for the no. of degrees of freedom.

Table A5.3.1A-12

T-TEST PROCEDURE SUMMARY FOR BETWEEN STATION COMPARISONS OF ALLUVIAL WELLS

Variables	Locations WA03-WA05	Locations WA03-WA06	Locations WA03-WA08	Locations WA06-WA05	Locations WA06-WA08	Locations WA05-WA08
pH	R	R	R	R	R	R
B	R	R	R	R	R	R
F	R	R	R	R	R	R
As	R	R	R	R	R	R
Mb	R	A	R	R	R	R
SO_4	R	A	A	R	A	R
Na	R	A	R	R	A	R
NH_3	R	R	R	R	R	R
Spec Cond	R	A	A	A	A	R
TDS	R	A	R	R	R	R
Level	R	R	R	A	R	R

Note: Table entries indicate acceptance (A) or rejection (R) of null hypothesis
H_0: The paired station means are not equal (90% confidence limit).

APPENDIX A5.3.1B

Linear Regression Data for Alluvial Wells

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------------------------------------------------------------- LOC=WA01 --------------------------------------------------------------

OBS YR MO LIST TOC PHENOLS PH   B      F    AS      YRMO     PRED1      PRED2    PRED3       PRED4       RESID1    RESID2     RESID3     RESID4

 1 74 10    1   7      .    7.8 0.60 3.40 0.005 74.7500 8.53227  0.363242 1.69292 -0.00060517 -0.73227  0.23676  1.70708  0.0058052
 2 75  5    2   8      .    8.4 0.10 1.20 0.002 75.3333 8.42674  0.298295 1.44959  0.00101783 -0.02674 -0.10830 -0.24959  0.0009622
 3 75  9    3   2      .    8.4 0.30 0.70 0.006 75.6667 8.36644  0.261183 1.31054  0.00205955  0.03356  0.03882 -0.61054  0.0039405
 4 76  2    4   .      .    8.4 0.01 0.70   .   76.0833 8.29107  0.214793 1.13674  0.00336169  0.10893 -0.20479 -0.43674   .
 5 76  4    5   .      .    8.3   .  0.90   .   76.2500 8.26092  0.196237 1.06721  0.00388255  0.03908    .      -0.16721   .
 6 76  5    6   .      .    8.3   .  0.60 0.001 76.3333 8.24584  0.166959 1.03245  0.00414297  0.05416    .      -0.43245 -0.0031430
 7 76  6    7   .      .    8.7   .  0.60 0.001 76.4167 8.23077  0.177680 0.99769  0.00440340  0.46923    .      -0.39769 -0.0034034
 8 76  7    8   .      .    8.3 0.10 0.80 0.001 76.5000 8.21569  0.168402 0.96293  0.00466383  0.08431 -0.06840 -0.16293 -0.0036638
 9 76  8    9   .      .    8.4   .  0.80 0.001 76.5833 8.20062  0.159124 0.92817  0.00492426  0.19938    .      -0.12817 -0.0039243
10 76  9   10   .      .    8.4   .  0.40 0.001 76.6667 8.18554  0.149846 0.89341  0.00518469  0.21446    .      -0.49341 -0.0041847
11 76 10   11   .      .    8.6 0.08 1.00 0.002 76.7500 8.17047  0.140568 0.85865  0.00544512  0.42953 -0.06057  0.14135 -0.0034451
12 77 12   12   .      .    7.5 0.12 0.91 0.020 77.9167 7.95942  0.010675 0.37199  0.00909112 -0.45942  0.10932  0.53801  0.0109089
13 78  3   13   .    0.002  7.5 0.04 0.96 0.010 78.1667 7.91419 -0.017159 0.26771  0.00987240 -0.41419  0.05716  0.69229  0.0001276

------------------------------------------------------------- LOC=WA02 --------------------------------------------------------------

 OBS  YR MO LIST TOC PHENOLS PH   B    F   AS      YRMO     PRED1     PRED2   PRED3         PRED4   RESID1    RESID2    RESID3   RESID4

 14   74 10  1    7     .    7.4 1.7 5.0 0.010 74.7500 8.03374  1.12311 3.76141  0.00758587 -0.63374  0.57699  1.2386  0.0024141
 15   75  5  2    2     .    8.6 0.1 2.0 0.002 75.3333 8.09471  0.70770 2.96880  0.00529778  0.50529 -0.60770 -0.9688 -0.0032978
 16   75  9  3    2     .    8.6 0.2 1.5   .   75.6667 8.12955  0.47033 2.51588  0.00399030  0.47045 -0.27033 -1.0159   .
 17   76  5  4    .     .    8.3  .  1.6 0.001 76.3333 8.19923 -0.00443 1.61003  0.00137535  0.10077    .     -0.0100 -0.0003753
 18   76 10  5    .     .    7.8 0.0 1.8 0.001 76.7500 8.24279 -0.30115 1.04388 -0.00025900 -0.44278  0.30115  0.7561  0.0012590

------------------------------------------------------------- LOC=WA03 --------------------------------------------------------------

OBS  YR MO LIST TOC PHENOLS PH   B      F    AS      YRMO     PRED1      PRED2      PRED3    PRED4       RESID1    RESID2     RESID3 RESID4

19   74 10   1   7     .    7.5 0.70 1.90 0.004 74.7500 8.13837  0.42704   1.12202 0.0049515 -0.63837  0.27296   0.77798 -0.0009515
20   75  9   2   3     .    8.4 0.10 0.36   .   75.6667 8.13206  0.27024   0.77280 0.0072246  0.26794 -0.17024  -0.41280   .
21   76  2   3   .     .    8.3 0.01 0.30   .   76.0833 8.12920  0.15897   0.61406 0.0082579  0.17080 -0.18897  -0.31406   .
22   76  4   4   .     .    8.1   .  0.40 0.050 76.2500 8.12805  0.17046   0.55056 0.0086712 -0.02805    .      -0.15056  0.0413288
23   76  5   5   .     .    8.1   .  0.40 0.001 76.3333 8.12748  0.15621   0.51882 0.0088778 -0.02748    .      -0.11662 -0.0078778
24   76  6   6   .     .    8.4   .  0.30 0.001 76.4167 8.12691  0.14195   0.48707 0.0090845  0.27309    .      -0.18707 -0.0080845
25   76  7   7   .     .    8.1 0.03 0.30 0.001 76.5000 8.12634  0.12770   0.45532 0.0092911 -0.02634 -0.09770  -0.15532 -0.0082911
26   76  8   8   .     .    8.3   .  0.40 0.002 76.5833 8.12576  0.11344   0.42357 0.0094978  0.17424    .      -0.02357 -0.0074978
27   76  9   9   .     .    8.3   .  0.40 0.001 76.6667 8.12519  0.09919   0.39183 0.0097044  0.17481    .       0.00817 -0.0087044
28   76 10  10   .     .    8.4 0.10 0.40 0.003 76.7500 8.12462  0.08494   0.36008 0.0099111  0.27538  0.01506   0.03992 -0.0069111
29   78  1  11   .     .    7.5 0.04 0.42 0.020 78.0000 8.11602 -0.12888  -0.11613 0.0130108 -0.61602  0.16888   0.53613  0.0069892

------------------------------------------------------------- LOC=WA05 --------------------------------------------------------------

 OBS  YR MO LIST TOC PHENOLS PH   B     F    AS      YRMO     PRED1      PRED2      PRED3     PRED4      RESID1    RESID2   RESID3      RESID4

 30   74 10  1    7     .    7.8 1.20 1.5 0.050 74.7500 8.23273  0.794793   2.38578 0.0208828 -0.43273  0.40521 -0.8858   0.029117
 31   75  5  2    3     .    8.5 0.25 5.0 0.003 75.3333 8.19098  0.635438   1.93675 0.0179920  0.30902 -0.38544  3.0632  -0.014992
 32   75  9  3    2     .    8.3 0.50 0.2 0.004 75.6667 8.16713  0.544378   1.68017 0.0163402  0.13287 -0.04438 -1.4802  -0.012340
 33   76  5  4    .     .    8.2   .  0.4 0.002 76.3333 8.11942  0.362258   1.16699 0.0130364  0.08058    .     -0.7670  -0.011036
 34   76 10  5    .     .    8.2 0.10 0.4 0.005 76.7500 8.08960  0.248433   0.84626 0.0109716  0.11040 -0.14843 -0.4463  -0.005972
 35   78  1  6    .     .    7.8 0.08 0.4 0.020 78.0000 8.00014 -0.093041  -0.11595 0.0047770 -0.20014  0.17304  0.5160   0.015223
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                                              REGRESSION OF WATER QUALITY PARAMETERS VS TIME        13:39 MONDAY, DECEMBER 11, 1978  102

------------------------------------------------------------- LOC=WA06 -------------------------------------------------------------

OBS YR MO LIST TOC PHENOLS PH   B      F    AS      YRMO     PRED1      PRED2     PRED3     PRED4      RESID1    RESID2    RESID3    RESID4

36  74 10   1   7     .    7.4 1.40 1.90 0.004 74.7500 8.07446  0.99063  1.11619 0.0035518 -0.67446  0.40937  0.78381  0.0004482
37  75  9   2   6     .    8.5 0.60 0.36 0.002 75.6667 8.13028  0.63350  0.78887 0.0064823  0.36972 -0.03350 -0.42887 -0.0044823
38  76  2   3   .     .    8.4 0.08 0.30   .   76.0833 8.15566  0.47117  0.64009 0.0078143  0.24434 -0.39117 -0.34009   .
39  76  4   4   .     .    8.2   .  0.40 0.050 76.2500 8.16581  0.40623  0.58058 0.0083471  0.03419    .      -0.18058  0.0416529
40  76  5   5   .     .    8.2   .  0.50 0.001 76.3333 8.17088  0.37377  0.55082 0.0086135  0.02912    .      -0.05082 -0.0076135
41  76  6   6   .     .    8.6   .  0.30 0.002 76.4167 8.17596  0.34130  0.52106 0.0088799  0.42404    .      -0.22106 -0.0068799
42  76  7   7   .     .    8.1 0.10 0.40 0.002 76.5000 8.18103  0.30883  0.49131 0.0091463 -0.08103 -0.20883 -0.09131 -0.0071463
43  76  8   8   .     .    8.4   .  0.40 0.001 76.5833 8.18611  0.27637  0.46155 0.0094127  0.21389    .      -0.06155 -0.0084127
44  76  9   9   .     .    8.3   .  0.40 0.002 76.6667 8.19118  0.24390  0.43179 0.0096791  0.10882    .      -0.03179 -0.0076791
45  76 10  10   .     .    8.0 0.06 0.50 0.004 76.7500 8.19626  0.21143  0.40204 0.0099456 -0.19626 -0.15143  0.09796 -0.0059456
46  78  1  11   .     .    7.3 0.10 0.48 0.020 78.0000 8.27238 -0.27557 -0.04431 0.0139417 -0.47238  0.37557  0.52431  0.0060583

------------------------------------------------------------- LOC=WA07 -------------------------------------------------------------

OBS YR MO LIST TOC PHENOLS PH   B      F    AS      YRMO     PRED1      PRED2     PRED3     PRED4      RESID1    RESID2    RESID3    RESID4

47  74 10   1   8     .    8.4 1.40 1.90 0.010 74.7500 8.43184  0.55486  0.87142 0.0052139 -0.03184  0.54514  1.02858  0.0047861
48  75  5   2   9     .    8.2 0.25 0.20 0.002 75.3333 8.37195  0.65826  0.66056 0.0064714 -0.17195 -0.40826 -0.46056 -0.0044714
49  75  9   3   3     .    8.3 0.50 0.13 0.003 75.6667 8.33773  0.54592  0.54007 0.0071900 -0.03773 -0.04592 -0.41007 -0.0041900
50  76  2   4   .     .    8.3 0.30 0.10   .   76.0833 8.29496  0.40550  0.38945 0.0080882  0.00504 -0.10550 -0.28945   .
51  76  4   5   .     .    8.3   .  0.20 0.050 76.2500 8.27785  0.34933  0.32921 0.0084475  0.02215    .      -0.12921  0.0415525
52  76  5   6   .     .    8.2   .  0.20 0.001 76.3333 8.26930  0.32125  0.29908 0.0086271 -0.06930    .      -0.09908 -0.0076271
53  76  6   7   .     .    8.5   .  0.20 0.001 76.4167 8.26074  0.29316  0.26896 0.0088068  0.23926    .      -0.06896 -0.0078068
54  76  7   8   .     .    8.3 0.10 0.20 0.001 76.5000 8.25219  0.26508  0.23884 0.0089864  0.04781 -0.16508 -0.03884 -0.0079864
55  76  8   9   .     .    8.3   .  0.20 0.001 76.5833 8.24363  0.23699  0.20872 0.0091660  0.05637    .      -0.00872 -0.0081660
56  76  9  10   .     .    8.4   .  0.20 0.002 76.6667 8.23508  0.20891  0.17859 0.0093457  0.16492    .       0.02141 -0.0073457
57  76 10  11   .     .    8.2 0.08 0.10 0.003 76.7500 8.22652  0.18082  0.14847 0.0095253 -0.02652 -0.10082 -0.04847 -0.0065253
58  78  1  12   .     .    7.9 0.04 0.20 0.020 78.0000 8.09820 -0.24045 -0.30338 0.0122200 -0.19820  0.28045  0.50338  0.0077800

------------------------------------------------------------- LOC=WA08 -------------------------------------------------------------

OBS YR MO LIST TOC PHENOLS PH   B    F    AS     YRMO    PRED1        PRED2    PRED3       PRED4      RESID1    RESID2    RESID3      RESID4

59  74 10   1   8     .    7.6 0.70 0.8 0.004 74.7500 8.29323  0.385199 0.441738 0.0008526 -0.69323  0.31481  0.35826  0.0031474
60  75  5   2   9     .    8.5 0.17 0.2 0.002 75.3333 8.23939  0.321969 0.392071 0.0026093  0.26061 -0.15197 -0.19207 -0.0006093
61  75  9   3   3     .    8.7 0.10 0.2 0.005 75.6667 8.20863  0.285843 0.363690 0.0036131  0.49137 -0.18584 -0.16369  0.0013869
62  76  5   4   .     .    8.3   .  0.2 0.001 76.3333 8.14711  0.213591 0.306929 0.0056207  0.15289    .      -0.10693 -0.0046207
63  76 10   5   .     .    8.1 0.06 0.2 0.002 76.7500 8.10865  0.168433 0.271452 0.0068755 -0.00865 -0.10843 -0.07145 -0.0048755
64  78  1   6   .     .    7.8 0.08 0.3 0.020 78.0000 7.99330  0.032961 0.165024 0.0106398 -0.19330  0.04704  0.13498  0.0093602
65  78  3   7   .     .    8.3 0.03 0.2 0.010 78.1667 7.97792  0.014898 0.150833 0.0111417  0.32208  0.01510  0.04917 -0.0011417
66  78  9   8   .   0.003  7.6 0.03 0.1 0.010 78.6667 7.93177 -0.039292 0.108262 0.0126474 -0.33177  0.06929 -0.00826 -0.0026474
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--------------------------------------------------------------- LOC=WA09 ----------------------------------------------------------------

  OBS YR MO LIST TOC PHENOLS PH   B    F   AS      YRMO   PRED1   PRED2    PRED3     PRED4    RESID1  RESID2    RESID3      RESID4

  67  74 10   1   6     .    7.4 0.70 0.8 0.003 74.7500 8.141 0.435738 0.459274 0.0015689 -0.741  0.26426  0.34073  0.0014311
  68  75  5   2   2     .    8.5 0.18 0.2 0.003 75.3333 8.099 0.425790 0.408107 0.0032239  0.401 -0.24579 -0.20611 -0.0002239
  69  75  9   3   1     .    8.2 0.70 0.3 0.008 75.6667 8.075 0.420106 0.378869 0.0041696  0.125  0.27989 -0.07887  0.0038304
  70  76  5   4   .     .    8.4  .   0.2 0.001 76.3333 8.027 0.408737 0.320393 0.0060611  0.373   .      -0.12039 -0.0050611
  71  76 10   5   .     .    8.2 0.06 0.2 0.002 76.7500 7.997 0.401632 0.283845 0.0072432  0.203 -0.34163 -0.08385 -0.0052432
  72  78  1   6   .     .    7.8 0.04 0.2 0.020 78.0000 7.907 0.380315 0.174202 0.0107896 -0.107 -0.34032  0.02580  0.0092104
  73  78  3   7   .     .    7.9 0.03 0.2 0.010 78.1667 7.895 0.377473 0.159583 0.0112625  0.005 -0.34747  0.04042 -0.0012625
  74  78  9   8   .   0.002  7.6 1.10 0.2 0.010 78.6667 7.859 0.368946 0.115726 0.0126811 -0.259  0.73105  0.08427 -0.0026811

--------------------------------------------------------------- LOC=WA10 ----------------------------------------------------------------

OBS YR MO LIST TOC PHENOLS PH   B    F   AS      YRMO    PRED1       PRED2   PRED3      PRED4     RESID1   RESID2    RESID3     RESID4

75  74 10   1   3     .    8.0 0.70 0.8 0.001 74.7500 8.29677   0.601979 0.468236 0.0001263 -0.28677  0.09802  0.33176  0.0008737
76  75  5   2   7     .    8.2 0.17 0.2 0.003 75.3333 8.19704   0.495150 0.424664 0.0023165  0.00296 -0.32515 -0.22466  0.0006835
77  75  9   3   3     .    8.3 0.80 0.3 0.008 75.6667 8.14577   0.434105 0.399767 0.0035680  0.15423  0.36590 -0.09977  0.0044320
78  76  5   4   .     .    8.2  .   0.3 0.001 76.3333 8.04322   0.312015 0.349971 0.0060710  0.15678   .      -0.04997 -0.0050710
79  76 10   5   .     .    8.2 0.00 0.2 0.002 76.7500 7.97913   0.235709 0.318848 0.0076354  0.22087 -0.23571 -0.11885 -0.0056354
80  78  1   6   .     .    7.7 0.04 0.3 0.020 78.0000 7.78685   0.006790 0.225481 0.0123285 -0.08685  0.03321  0.07452  0.0076715
81  78  3   7   .     .    7.6 0.04 0.3 0.010 78.1667 7.76121  -0.023732 0.213032 0.0129543 -0.16121  0.06373  0.08697 -0.0029543

--------------------------------------------------------------- LOC=WA11 ----------------------------------------------------------------

OBS YR MO LIST TOC PHENOLS PH   B    F   AS      YRMO    PRED1    PRED2    PRED3      PRED4     RESID1   RESID2    RESID3      RESID4

82  74 10   1   3     .    7.4 0.60 0.5 0.009 74.7500 8.15690 0.478228 0.316393 0.0025463 -0.75899  0.12177  0.183607  0.0064537
83  75  5   2   1     .    8.4 0.40 0.2 0.003 75.3333 8.11157 0.431523 0.292893 0.0039846  0.28843 -0.03152 -0.092893 -0.0009846
84  75  9   3   2     .    8.4 0.50 0.2 0.002 75.6667 8.08452 0.404834 0.279464 0.0048065  0.31548  0.09517 -0.079464 -0.0028065
85  76  5   4   .     .    8.4  .   0.2 0.001 76.3333 8.03043 0.351457 0.252607 0.0064504  0.36957   .      -0.052607 -0.0054504
86  76 10   5   .     .    8.2 0.08 0.2 0.004 76.7500 7.99662 0.318096 0.235821 0.0074777  0.20338 -0.23810 -0.035821 -0.0034777
87  78  1   6   .     .    7.9 0.04 0.2 0.020 78.0000 7.99519 0.218013 0.185464 0.0105599  0.00481 -0.17801  0.014536  0.0094401
88  78  3   7   .     .    7.5 0.04 0.2 0.010 78.1667 7.88167 0.204669 0.178750 0.0109708 -0.38167 -0.16467  0.021250 -0.0009708
89  78  9   8   .   0.001  7.8 0.56 0.2 0.010 78.6667 7.84110 0.164636 0.158607 0.0122037 -0.04110  0.39536  0.041393 -0.0022037

--------------------------------------------------------------- LOC=WA12 ----------------------------------------------------------------

 OBS YR MO LIST TOC PHENOLS PH   B    F   AS      YRMO    PRED1      PRED2   PRED3      PRED4     RESID1   RESID2   RESID3      RESID4

 90  74 10   1   3     .    7.3 1.20 0.7 0.008 74.7500 8.01563   2.33702 0.858452 0.0035835 -0.71563 -1.1370 -0.15865  0.0044165
 91  75  5   2   7     .    8.1 5.20 1.7 0.002 75.3333 7.97746   1.94025 0.736786 0.0048618  0.12254  3.2598  0.96321 -0.0028618
 92  75  9   3   2     .    8.5 0.20 0.2 0.009 75.6667 7.95565   1.71352 0.667262 0.0055923  0.54435 -1.5135 -0.46726  0.0034077
 93  76  5   4   .     .    8.2  .   0.2 0.001 76.3333 7.91204   1.26007 0.528214 0.0070532  0.28796   .     -0.32821 -0.0060532
 94  76 10   5   .     .    8.0 0.01 0.2 0.003 76.7500 7.88477   0.97667 0.441310 0.0079663  0.11523 -0.9667 -0.24131 -0.0049663
 95  78  1   6   .     .    7.9 0.04 0.2 0.020 78.0000 7.80299   0.12645 0.180595 0.0107056  0.09701 -0.0865  0.01940  0.0092944
 96  78  3   7   .     .    7.4 0.09 0.2 0.010 78.1667 7.79208   0.01309 0.145833 0.0110708 -0.39208  0.0769  0.05417 -0.0010708
 97  78  9   8   .   0.001  7.7 0.04 0.2 0.010 78.6667 7.75937  -0.32700 0.041548 0.0121665 -0.05937  0.3670  0.15845 -0.0021665
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------------------------------------------------------------ LOC=WA01 ------------------------------------------------------------

OBS  YR  MO  DISSOXY  MOLY   SO4   NA    NH3      YRMO       PRED1      PRED2     PRED3      PRED4     RESID1     RESID2    RESID3    RESID4

  1  74  10     .     0.02   530   270    0.10   74.7500   0.0184663   565.330   252.680   1.30896    0.001534    -35.33    17.320   -1.2090
  2  75   5     .     0.04   420   240    0.30   75.3333   0.0252124   511.223   247.385   1.34375    0.014788    -91.22    -7.385   -1.0437
  3  75   9     .     0.02   440   250    0.30   75.6667   0.0290674   480.278   244.474   1.36363   -0.009067    -40.28     5.526   -1.0636
  4  76   2     .     0.04   463   246    0.02   76.0833   0.0338860   441.592   240.834   1.38842    0.006114     21.41     5.166   -1.3684
  5  76   4     .       .    480   254    0.05   76.2500   0.0358135   426.118   239.379   1.39835        .         53.88    14.621   -1.3484
  6  76   5     .       .    447   240   15.50   76.3333   0.0367772   418.382   238.651   1.40332        .         28.62     1.349   14.0967
  7  76   6     .       .    460   240    0.01   76.4167   0.0377409   410.645   237.923   1.40828        .         49.36     2.077   -1.3983
  8  76   7     .     0.04   474   240    0.01   76.5000   0.0387047   402.908   237.195   1.41324    0.001295     71.09     2.805   -1.4032
  9  76   8     .       .    470   244    0.13   76.5833   0.0396684   395.171   236.467   1.41821        .         74.83     7.533   -1.2882
 10  76   9     .       .    274   149    0.12   76.6667   0.0406321   387.435   235.740   1.42317        .       -113.43   -86.740   -1.3032
 11  76  10     .     0.02   419   240    0.10   76.7500   0.0415959   379.698   235.012   1.42814   -0.021596     39.30     4.988   -1.3281
 12  77  12    4.8    0.02     .   260      .    77.9167   0.0550891   271.353   224.822   1.45763   -0.035088       .      35.178       .
 13  78   3    4.0    0.10   140   220    0.17   78.1667   0.0579793   248.173   222.639   1.51253    0.042021   -108.17    -2.639   -1.3425

------------------------------------------------------------ LOC=WA02 ------------------------------------------------------------

OBS  YR  MO  DISSOXY  MOLY   SO4   NA    NH3      YRMO       PRED1      PRED2     PRED3      PRED4     RESID1      RESID2    RESID3    RESID4

 14  74  10     .     0.005  410   260   0.60   74.7500   0.0151328   325.086   221.179   0.685215   -0.010133    84.912    38.821   -0.08521
 15  75   5     .       .    210   160   1.10   75.3333   0.0190531   284.300   190.207   0.631731       .       -74.300   -30.207    0.46827
 16  75   9     .     0.040  200   140   0.20   75.6667   0.0212933   260.992   172.509   0.601169    0.018707   -60.992   -32.509   -0.40117
 17  76   5     .       .    218   138   0.40   76.3333   0.0257737   214.377   137.114   0.540044       .         3.623     0.886   -0.14004
 18  76  10     .     0.020  232   138   0.66   76.7500   0.0285739   185.243   114.991   0.501841   -0.008574    46.757    23.009    0.15816

------------------------------------------------------------ LOC=WA03 ------------------------------------------------------------

     OBS YR MO DISSOXY MOLY  SO4 NA  NH3    YRMO      PRED1     PRED2   PRED3     PRED4      RESID1    RESID2  RESID3   RESID4

     19  74 10    .    0.020 400 250 0.10 74.7500 0.0150862 361.889 184.632 0.0945607  0.0049138  38.111  65.368  0.005439
     20  75  9    .    0.007 330 120 0.10 75.6667 0.0164256 361.074 157.160 0.0840913 -0.0094256 -31.074 -37.160  0.015909
     21  76  2    .      .   346 127 0.02 76.0833 0.0170347 360.704 144.673 0.0793325      .      -14.704 -17.673 -0.059332
     22  76  4    .      .   370 127 0.05 76.2500 0.0172792 360.556 139.678 0.0774269      .        9.444 -12.678 -0.027427
     23  76  5    .      .   346 123 0.20 76.3333 0.0174000 360.481 137.181 0.0764772      .      -14.481 -14.181  0.123523
     24  76  6    .      .   360 124 0.01 76.4167 0.0175218 360.407 134.683 0.0755254      .       -0.407 -10.683 -0.065525
     25  76  7    .    0.020 361 124 0.01 76.5000 0.0176436 360.333 132.186 0.0745735  0.0023564   0.667  -8.186 -0.064574
     26  76  8    .      .   354 124 0.17 76.5833 0.0177653 360.259 129.689 0.0736219      .       -6.259  -5.689  0.096378
     27  76  9    .      .   359 125 0.02 76.6667 0.0178871 360.185 127.191 0.0726701      .       -1.185  -2.191 -0.052670
     28  76 10    .    0.020 358 120 0.10 76.7500 0.0180089 360.111 124.694 0.0717183  0.0019911  -2.111  -4.694  0.028282
     29  78  1   6.4   0.020 383 135   .  78.0000 0.0193356 359.000  87.232 0.0574419  0.0006644  24.000  47.768      .

------------------------------------------------------------ LOC=WA05 ------------------------------------------------------------

OBS  YR  MO  DISSOXY  MOLY   SO4   NA   NH3     YRMO       PRED1      PRED2     PRED3      PRED4      RESID1      RESID2    RESID3    RESID4

 30  74  10     .     0.02   500   290   0.1   74.7500   0.0286447   402.037   214.026   0.348953   -0.008645     97.96    75.974   -0.24895
 31  75   5     .     0.01   260   170   0.7   75.3333   0.0283661   368.562   198.895   0.286439   -0.018366   -108.56   -28.895    0.41356
 32  75   9     .     0.06   370   130   0.2   75.6667   0.0282070   349.433   190.249   0.250717    0.031793     20.57   -60.249   -0.05072
 33  76   5     .       .    263   157   0.1   76.3333   0.0278886   311.175   172.956   0.179272        .        -48.17   -15.956   -0.07927
 34  76  10     .     0.03   290   160   0.1   76.7500   0.0276896   287.264   162.148   0.134620    0.002310      2.74    -2.148   -0.03462
 35  78   1    6.8    0.02   251   161    .    78.0000   0.0270926   215.530   129.725   0.000662   -0.007093     35.47    31.275       .
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                                      REGRESSION OF WATER QUALITY PARAMETERS VS TIME       10:31 TUESDAY, DECEMBER 12, 1978  101

------------------------------------------------------------ LOC=WA06 ----------------------------------------------------------------

 OBS  YR  MO  DISSOXY  MOLY  SO4  NA   NH3    YRMO       PRED1       PRED2     PRED3       PRED4      RESID1       RESID2   RESID3   RESID4

  36  74  10     .       .   400  300  0.10  74.7500   0.0550089   403.873   240.109   0.236047        .          -3.873   59.891  -0.13605
  37  75   9     .     0.04  330  180  0.50  75.6667   0.0455901   365.472   210.714   0.160155   -0.0055901    -35.472  -30.714   0.33984
  38  76   2     .     0.05  385  177  0.02  76.0833   0.0413088   348.016   197.352   0.125659    0.0086912     36.984  -20.352  -0.10566
  39  76   4     .       .   360  183  0.05  76.2500   0.0395963   341.033   192.008   0.111863        .          18.967   -9.008  -0.06186
  40  76   5     .       .   370  189  0.20  76.3333   0.0387400   337.542   189.335   0.104961        .          32.458   -0.335   0.09504
  41  76   6     .       .   353  177  0.06  76.4167   0.0378838   334.051   186.663   0.098062        .          18.949   -9.663  -0.03806
  42  76   7     .     0.03  321  177  0.01  76.5000   0.0370275   330.560   183.991   0.091163   -0.0070275     -9.560   -6.991  -0.08116
  43  76   8     .       .   305  170  0.11  76.5833   0.0361713   327.069   181.318   0.084264        .         -22.069  -11.318   0.02574
  44  76   9     .       .   307  168  0.01  76.6667   0.0353150   323.577   178.646   0.077364        .         -16.577  -10.646  -0.06736
  45  76  10     .     0.04  300  168  0.10  76.7500   0.0344587   320.086   175.974   0.070465    0.0055413    -20.086   -7.974   0.02953
  46  78   1    6.8    0.02  263  184    .   78.0000   0.0216149   267.718   135.890  -0.033023   -0.0016149     -4.718   48.110      .

------------------------------------------------------------ LOC=WA07 ----------------------------------------------------------------

 OBS  YR  MO  DISSOXY  MOLY  SO4  NA   NH3    YRMO       PRED1       PRED2     PRED3      PRED4    RESID1      RESID2    RESID3    RESID4

  47  74  10     .     0.01  480  380  0.10  74.7500   0.0387677   348.763   238.950    2.0027  -0.028768    131.237   141.050   -1.9027
  48  75   5     .       .   260  140  5.20  75.3333   0.0398646   330.303   208.233    1.3909      .         -70.303   -68.233    3.8091
  49  75   9     .     0.04  300  140  0.20  75.6667   0.0404914   319.755   190.680    1.0413  -0.000491    -19.755   -50.680   -0.8413
  50  76   2     .     0.09  282  137  0.02  76.0833   0.0412749   306.570   168.739    0.6043   0.048725    -24.570   -31.739   -0.5843
  51  76   4     .       .   300  142  0.05  76.2500   0.0415883   301.296   159.963    0.4295      .          -1.296   -17.963   -0.3795
  52  76   5     .       .   230  141  0.30  76.3333   0.0417450   298.659   155.575    0.3421      .         -68.659   -14.575   -0.0421
  53  76   6     .       .   281  137  0.10  76.4167   0.0419017   296.022   151.186    0.2547      .         -15.022   -14.186   -0.1547
  54  76   7     .     0.02  281  135  0.01  76.5000   0.0420584   293.384   146.798    0.1673  -0.022058    -12.384   -11.798   -0.1573
  55  76   8     .       .   258  134  0.12  76.5833   0.0422151   290.747   142.410    0.0799      .         -32.747    -8.410    0.0401
  56  76   9     .       .   307  138  0.01  76.6667   0.0423718   288.110   138.022   -0.0075      .          18.890    -0.022    0.0175
  57  76  10     .     0.07  313  142  0.10  76.7500   0.0425285   285.473   133.634   -0.0949   0.027471     27.527     8.366    0.1949
  58  78   1     6     0.02  313  136    .   78.0000   0.0448791   245.917    67.810   -1.4059  -0.024879     67.083    68.190      .

------------------------------------------------------------ LOC=WA08 ----------------------------------------------------------------

 OBS  YR  MO  DISSOXY  MOLY  SO4  NA   NH3    YRMO       PRED1       PRED2     PRED3     PRED4     RESID1      RESID2    RESID3    RESID4

  59  74  10     .     0.01  480  290  0.10  74.7500   0.0142734   393.510   181.136   0.38560  -0.004273     86.490   108.864   -0.2856
  60  75   5     .       .   350   93  2.70  75.3333   0.0183506   396.002   168.659   0.60081      .         -46.002   -75.659    2.0992
  61  75   9     .     0.04  370  130  0.20  75.6667   0.0206805   397.426   161.530   0.72378   0.019319    -27.426   -31.530   -0.5238
  62  76   5     .       .   346  122  0.30  76.3333   0.0253403   400.273   147.271   0.96973      .         -54.273   -25.271   -0.6697
  63  76  10     .     0.02  403  124  0.10  76.7500   0.0282526   402.053   138.359   1.12345  -0.008253      0.947   -14.359   -1.0234
  64  78   1    6.3    0.02  416  157    .   78.0000   0.0369896   407.392   111.623   1.58460  -0.016990      8.608    45.377      .
  65  78   3    5.9    0.01  440   88  0.08  78.1667   0.0381546   408.104   108.058   1.64605  -0.028155     31.896   -20.058   -1.5661
  66  78   9    6.7    0.08  410  130  3.30  78.6667   0.0416494   410.240    97.364   1.83055   0.038351     -0.240    32.636    1.4695
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------------------------------------------------------------ LOC=WA09 ------------------------------------------------------------

OBS  YR  MO  DISSOXY  MOLY   SO4   NA   NH3    YRMO       PRED1      PRED2     PRED3     PRED4      RESID1      RESID2    RESID3   RESID4

67   74  10     .     0.02   360  150  0.20  74.7500  0.0424543  327.510  124.458  0.986370  -0.022454      32.49   25.542  -0.78637
68   75   5     .     0.02   260   93  2.70  75.3333  0.0390148  323.114  120.375  0.839577  -0.019015     -63.11  -27.375   1.86042
69   75   9     .     0.09   360  130  0.20  75.6667  0.0354781  320.601  118.042  0.755696   0.054522      39.40   11.959  -0.55570
70   76   5     .       .    255   98  0.30  76.3333  0.0304045  315.576  115.375  0.587932    .           -60.58  -15.375  -0.28793
71   76  10     .     0.02   300  102  0.10  76.7500  0.0272335  312.436  110.458  0.483060  -0.007233     -12.44   -8.458  -0.38306
72   78   1    6.8    0.02   417  114   .    78.0000  0.0177205  303.015  101.708  0.169524   0.002280     113.99   12.292    .
73   78   3    8.8    0.01   410   99  0.03  78.1667  0.0164521  301.753  100.542  0.106583  -0.006452     108.25   -1.542  -0.07658
74   78   9   11.2    0.01   140  100  0.25  78.6667  0.0126469  297.990   97.042  0.000761  -0.002647    -157.99    2.958   0.24924

------------------------------------------------------------ LOC=WA10 ------------------------------------------------------------

OBS  YR  MO  DISSOXY  MOLY   SO4   NA   NH3    YRMO       PRED1      PRED2     PRED3     PRED4      RESID1      RESID2    RESID3   RESID4

75   74  10     .     0.001  450  160  0.10  74.7500  0.0039839  440.650  150.723  0.274032  -0.0029839     9.350    9.277  -0.17403
76   75   5     .       .    430  110  0.10  75.3333  0.0070931  429.204  146.103  0.245607    .            0.796  -36.103  -0.14561
77   75   9     .     0.010  420  190  0.60  75.6667  0.0088699  422.664  143.463  0.229364   0.0011301    -2.664   46.537   0.37064
78   76   5     .       .    379  134  0.30  76.3333  0.0124233  409.583  138.193  0.196879    .          -30.583   -4.193   0.10312
79   76  10     .     0.020  419  106  0.10  76.7500  0.0146442  401.408  134.883  0.176575   0.0053558    16.592  -28.883  -0.07657
80   78   1    6.7    0.020  407  142   .    78.0000  0.0213069  376.881  124.983  0.115664  -0.0013069    30.119   17.017    .
81   78   3    8.3    0.020  350  120  0.03  78.1667  0.0221952  373.611  123.663  0.107543  -0.0021952   -23.611   -3.663  -0.07754

------------------------------------------------------------ LOC=WA11 ------------------------------------------------------------

OBS  YR  MO  DISSOXY  MOLY   SO4   NA   NH3    YRMO       PRED1      PRED2     PRED3     PRED4      RESID1      RESID2    RESID3   RESID4

82   74  10     .       .    480  180  0.10  74.7500  0.0555726  467.773  155.285  -0.43248    .            12.23   24.715   0.5325
83   75   5     .       .    440  140  0.40  75.3333  0.0517761  461.548  153.003  -0.02153    .           -21.55  -13.003   0.4215
84   75   9     .     0.02   450  140  0.20  75.6667  0.0496066  457.991  151.699   0.71330  -0.029607      -7.99  -11.699  -0.5133
85   76   5     .       .    444  145  0.30  76.3333  0.0452677  450.977  149.092   0.68296    .            -6.98   -4.092  -0.3830
86   76  10     .     0.10   472  142  0.10  76.7500  0.0425559  446.430  147.462   0.97649   0.057444      25.57   -5.462  -0.8765
87   78   1    6.5    0.02   539  154   .    78.0000  0.0344204  433.091  142.573   1.85710  -0.014420     105.91   11.427    .
88   78   3    7.9    0.01   320  130  0.22  78.1667  0.0333357  431.313  141.921   1.97451  -0.023336    -111.31  -11.921  -1.7545
89   78   9    8.5    0.04   430  150  4.40  78.6667  0.0300815  425.977  139.965   2.32676   0.009919       4.02   10.035   2.0732

------------------------------------------------------------ LOC=WA12 ------------------------------------------------------------

OBS  YR  MO  DISSOXY  MOLY   SO4   NA   NH3    YRMO       PRED1      PRED2     PRED3      PRED4     RESID1      RESID2    RESID3   RESID4

90   74  10     .       .    480  730  0.10  74.7500  0.0366269  486.222  372.555   0.465131    .           -6.222   357.45  -0.36513
91   75   5     .     0.02   490  150  1.10  75.3333  0.0358084  480.533  326.145   0.393443  -0.015808     9.467  -176.14   0.70656
92   75   9     .     0.06   490  140  0.10  75.6667  0.0353407  477.283  299.625   0.352479   0.024659    12.717  -159.62  -0.25248
93   76   5     .       .    453  143  0.30  76.3333  0.0344052  470.782  246.585   0.270551    .          -17.782  -103.58   0.02945
94   76  10     .     0.03   446  142  0.10  76.7500  0.0338205  466.719  213.435   0.219346  -0.003821   -20.719   -71.44  -0.11935
95   78   1    6.6    0.02   518  159   .    78.0000  0.0320666  454.529  113.985   0.065730  -0.012067    63.471    45.01    .
96   78   3    6.2    0.02   440  130  0.03  78.1667  0.0318327  452.904  100.725   0.045249  -0.011833   -12.904    29.27  -0.01525
97   78   9    7.3    0.05   420  140  0.00  78.6667  0.0311311  448.028   60.945  -0.016198   0.018869   -28.028    79.05   0.01620
```

APPENDIX A5.3.1C

T-TEST Procedure Results
for
Alluvial Wells WA03, WA05, WA06, WA08

```
                              S T A T I S T I C A L   A N A L Y S I S   S Y S T E M          15:25 WEDNESDAY, FEBRUARY 28, 1979   1

                                                  TTEST PROCEDURE

VARIABLE: MOLY

LOC          N           MEAN         STD DEV       STD ERROR         MINIMUM          MAXIMUM    VARIANCES          T        DF   PROB > |T|

WA03         5     0.01740000      0.00581378      0.00260000      0.00700000       0.02000000    UNEQUAL      -1.1795       4.7       0.2946
WA05         5     0.02800000      0.01923538      0.00860233      0.01000000       0.06000000    EQUAL        -1.1795       8.0       0.2721

FOR HO: VARIANCES ARE EQUAL, F'=   10.95 WITH 4 AND 4 DF      PROB > F'= 0.0397
--------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: SO4

LOC          N           MEAN         STD DEV       STD ERROR         MINIMUM          MAXIMUM    VARIANCES          T        DF   PROB > |T|

WA03        11   360.45454545     18.94393642      5.71181174    330.00000000     400.00000000    UNEQUAL       0.9495       5.2       0.3845
WA05         6   322.33333333     97.34200875     39.73970866    251.00000000     500.00000000    EQUAL         1.2886      15.0       0.2171

FOR HO: VARIANCES ARE EQUAL, F'=   26.40 WITH 5 AND 10 DF      PROB > F'= 0.0001
--------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: NA

LOC          N           MEAN         STD DEV       STD ERROR         MINIMUM          MAXIMUM    VARIANCES          T        DF   PROB > |T|

WA03        11   136.27272727     37.93702916     11.43844467    120.00000000     250.00000000    UNEQUAL      -1.6205       7.5       0.1463
WA05         6   178.00000000     56.50840645     23.06946033    130.00000000     290.00000000    EQUAL        -1.8276      15.0       0.0876

FOR HO: VARIANCES ARE EQUAL, F'=    2.22 WITH 5 AND 10 DF      PROB > F'= 0.2655
--------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: NH3

LOC          N           MEAN         STD DEV       STD ERROR         MINIMUM          MAXIMUM    VARIANCES          T        DF   PROB > |T|

WA03        10     0.07800000      0.06795423      0.02148902      0.01000000       0.20000000    UNEQUAL      -1.3661       4.3       0.2400
WA05         5     0.24000000      0.26076810      0.11661904      0.10000000       0.70000000    EQUAL        -1.9044      13.0       0.0792

FOR HO: VARIANCES ARE EQUAL, F'=   14.73 WITH 4 AND 9 DF      PROB > F'= 0.0011
```

```
                                  S T A T I S T I C A L   A N A L Y S I S   S Y S T E M         11:44 WEDNESDAY, FEBRUARY 28, 1979

                                                   TTEST PROCEDURE

VARIABLE: PH

LOC        N           MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM   VARIANCES          T        DF   PROB > |T|

WA03      11     8.12727273      0.33193647      0.10008261      7.50000000      8.40000000   UNEQUAL      -0.0399      12.0       0.9689
WA05       6     8.13333333      0.28047579      0.11450376      7.80000000      8.50000000   EQUAL        -0.0378      15.0       0.9703

FOR H0: VARIANCES ARE EQUAL, F'=    1.40 WITH 10 AND 5 DF     PROB > F'= 0.7458
-------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: B

LOC        N           MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM   VARIANCES          T        DF   PROB > |T|

WA03       6     0.16333333      0.26553091      0.10840254      0.01000000      0.70000000   UNEQUAL      -1.1218       6.1       0.3042
WA05       5     0.42600000      0.46409051      0.20754758      0.08000000      1.20000000   EQUAL        -1.1811       9.0       0.2678

FOR H0: VARIANCES ARE EQUAL, F'=    3.05 WITH 4 AND 5 DF     PROB > F'= 0.2521
-------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: F

LOC        N           MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM   VARIANCES          T        DF   PROB > |T|

WA03      11     0.50727273      0.46426481      0.13998111      0.30000000      1.90000000   UNEQUAL      -1.0462       5.3       0.3408
WA05       6     1.31666667      1.86377753      0.76088399      0.20000000      5.00000000   EQUAL        -1.3979      15.0       0.1825

FOR H0: VARIANCES ARE EQUAL, F'=   16.12 WITH 5 AND 10 DF     PROB > F'= 0.0003
-------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: AS

LOC        N           MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM   VARIANCES          T        DF   PROB > |T|

WA03       9     0.00922222      0.01646039      0.00548680      0.00100000      0.05000000   UNEQUAL      -0.5054       9.8       0.6245
WA05       6     0.01400000      0.01885736      0.00769848      0.00200000      0.05000000   EQUAL        -0.5203      13.0       0.6116

FOR H0: VARIANCES ARE EQUAL, F'=    1.31 WITH 5 AND 8 DF     PROB > F'= 0.6963
```

```
                         S T A T I S T I C A L   A N A L Y S I S   S Y S T E M        14:16 WEDNESDAY, FEBRUARY 28, 1979

                                          TTEST PROCEDURE

VARIABLE: SPECCOND

LOC        N            MEAN          STD DEV        STD ERROR          MINIMUM          MAXIMUM    VARIANCES          T        DF   PROB > |T|

WA03      11   1378.09090909     121.07886235      36.50665059    1200.00000000    1559.00000000    UNEQUAL       0.5019       9.5       0.6271
WA05       6   1345.16666667     133.49219703      54.49796123    1200.00000000    1521.00000000    EQUAL         0.5175      15.0       0.6123

FOR HO: VARIANCES ARE EQUAL, F'=     1.22 WITH 5 AND 10 DF      PROB > F'= 0.7389
--------------------------------------------------------------------------------------------------------------------------------------------
VARIABLE: TDS

LOC        N            MEAN          STD DEV        STD ERROR          MINIMUM          MAXIMUM    VARIANCES          T        DF   PROB > |T|

WA03      10    952.30000000      66.08252416      20.89712899     807.00000000    1022.00000000    UNEQUAL      -0.1546       4.9       0.8833
WA05       5    962.40000000     138.39544790      61.89232586     851.00000000    1200.00000000    EQUAL        -0.1953      13.0       0.8482

FOR HO: VARIANCES ARE EQUAL, F'=     4.39 WITH 4 AND 9 DF      PROB > F'= 0.0612
```

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                                   S T A T I S T I C A L   A N A L Y S I S   S Y S T E M          11:33 WEDNESDAY, FEBRUARY 28, 1979  1

                                                        TTEST PROCEDURE

VARIABLE: PH

LOC        N           MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES         T        DF   PROB > |T|

WA05       6     8.13333333     0.28047579     0.11450376     7.80000000     8.50000000   UNEQUAL     -0.2551      12.4       0.8029
WA06      11     8.17272727     0.34377583     0.10365231     7.40000000     8.60000000   EQUAL       -0.2395      15.0       0.8139

FOR HO: VARIANCES ARE EQUAL, F'=     1.50 WITH 10 AND 5 DF      PROB > F'= 0.6836
--------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: B

LOC        N           MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES         T        DF   PROB > |T|

WA05       5     0.42600000     0.46409051     0.20754758     0.08000000     1.20000000   UNEQUAL      0.1193       9.0       0.9076
WA06       6     0.39000000     0.53617161     0.21889114     0.06000000     1.40000000   EQUAL        0.1176       9.0       0.9089

FOR HO: VARIANCES ARE EQUAL, F'=     1.33 WITH 5 AND 4 DF      PROB > F'= 0.8025
--------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: F

LOC        N           MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES         T        DF   PROB > |T|

WA05       6     1.31666667     1.86377753     0.76088399     0.20000000     5.00000000   UNEQUAL      1.0045       5.3       0.3589
WA06      11     0.54000000     0.45633321     0.13758964     0.30000000     1.90000000   EQUAL        1.3439      15.0       0.1990

FOR HO: VARIANCES ARE EQUAL, F'=    16.68 WITH 5 AND 10 DF      PROB > F'= 0.0003
--------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: AS

LOC        N           MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES         T        DF   PROB > |T|

WA05       6     0.01400000     0.01885736     0.00769848     0.00200000     0.05000000   UNEQUAL      0.5693       9.1       0.5830
WA06      10     0.00880000     0.01554778     0.00491664     0.00100000     0.05000000   EQUAL        0.5992      14.0       0.5586

FOR HO: VARIANCES ARE EQUAL, F'=     1.47 WITH 5 AND 9 DF      PROB > F'= 0.5786
```

```
                               S T A T I S T I C A L   A N A L Y S I S   S Y S T E M        15:26 WEDNESDAY, FEBRUARY 28, 1979

                                                  TTEST PROCEDURE

VARIABLE: MOLY

LOC       N           MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM    VARIANCES          T        DF    PROB > |T|

WA05      5     0.02800000      0.01923538      0.00860233      0.01000000      0.06000000    UNEQUAL      -0.8000       6.5        0.4521
WA06      5     0.03600000      0.01140175      0.00509902      0.02000000      0.05000000    EQUAL        -0.8000       8.0        0.4468

FOR HO: VARIANCES ARE EQUAL, F'=     2.85 WITH 4 AND 4 DF       PROB > F'= 0.3353
--------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: SO4

LOC       N           MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM    VARIANCES          T        DF    PROB > |T|

WA05      6   322.33333333     97.34200875     39.73970866    251.00000000    500.00000000    UNEQUAL      -0.3352       6.0        0.7489
WA06     11   336.27272727     40.62041583     12.24751619    268.00000000    400.00000000    EQUAL        -0.4209      15.0        0.6798

FOR HO: VARIANCES ARE EQUAL, F'=     5.74 WITH 5 AND 10 DF       PROB > F'= 0.0188
--------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: NA

LOC       N           MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM    VARIANCES          T        DF    PROB > |T|

WA05      6   178.00000000     56.50840645     23.06946033    130.00000000    290.00000000    UNEQUAL      -0.4032       7.5        0.6981
WA06     11   188.36363636     37.59593789     11.33560178    168.00000000    300.00000000    EQUAL        -0.4558      15.0        0.6550

FOR HO: VARIANCES ARE EQUAL, F'=     2.26 WITH 5 AND 10 DF       PROB > F'= 0.2555
--------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: NH3

LOC       N           MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM    VARIANCES          T        DF    PROB > |T|

WA05      5     0.24000000      0.26076810      0.11661904      0.10000000      0.70000000    UNEQUAL       0.9878       5.3        0.3664
WA06     10     0.11600000      0.14690889      0.04645667      0.01000000      0.50000000    EQUAL         1.1954      13.0        0.2533

FOR HO: VARIANCES ARE EQUAL, F'=     3.15 WITH 4 AND 9 DF       PROB > F'= 0.1410
```

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                              S T A T I S T I C A L   A N A L Y S I S   S Y S T E M                                     1
                                                                                               14:02 WEDNESDAY, FEBRUARY 28, 1979
                                                     TTEST PROCEDURE

VARIABLE: SPECCOND
LOC       N           MEAN         STD DEV        STD ERROR         MINIMUM          MAXIMUM    VARIANCES         T        DF  PROB > |T|
WA05      6  1345.16666667    133.49219703      54.49796123   1200.00000000    1521.00000000    UNEQUAL      -2.2303       7.6      0.0581
WA06     11  1481.18181818     90.78195656      27.37178978   1350.00000000    1650.00000000    EQUAL        -2.5063      15.0      0.0242

FOR H0: VARIANCES ARE EQUAL, F'=    2.16 WITH 5 AND 10 DF     PROB > F'= 0.2803
-------------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: TDS
LOC       N           MEAN         STD DEV        STD ERROR         MINIMUM          MAXIMUM    VARIANCES         T        DF  PROB > |T|
WA05      5   962.40000000    138.39544790      61.89232586    851.00000000    1200.00000000    UNEQUAL      -1.3911       6.0      0.2134
WA06     10  1058.40000000     96.52426293      30.52365203    912.00000000    1200.00000000    EQUAL        -1.5776      13.0      0.1387

FOR H0: VARIANCES ARE EQUAL, F'=    2.06 WITH 4 AND 9 DF     PROB > F'= 0.3394
```

```
                              S T A T I S T I C A L   A N A L Y S I S   S Y S T E M        11139 WEDNESDAY, FEBRUARY 28, 1979

                                                   TTEST PROCEDURE

VARIABLE: PH

LOC        N          MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES        T       DF  PROB > ITI

WA05       6    8.13333333     0.28047579     0.11450376     7.80000000     8.50000000   UNEQUAL     0.1124     11.9      0.9124
WA08       8    8.11250000     0.41209396     0.14569722     7.60000000     8.70000000   EQUAL       0.1062     12.0      0.9171

FOR H0: VARIANCES ARE EQUAL, F'=     2.16 WITH 7 AND 5 DF      PROB > F'= 0.4140
--------------------------------------------------------------------------------------------------------------------------------

VARIABLE: B

LOC        N          MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES        T       DF  PROB > ITI

WA05       5    0.42600000     0.46409051     0.20754758     0.08000000     1.20000000   UNEQUAL     1.1430      5.5      0.3004
WA08       7    0.16714286     0.23984122     0.09065146     0.03000000     0.70000000   EQUAL       1.2727     10.0      0.2319

FOR H0: VARIANCFS ARE EQUAL, F'=     3.74 WITH 4 AND 6 DF      PROB > F'= 0.1470
--------------------------------------------------------------------------------------------------------------------------------

VARIABLE: F

LOC        N          MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES        T       DF  PROB > ITI

WA05       6    1.31666667     1.86377753     0.76088399     0.20000000     5.00000000   UNEQUAL     1.3620      5.1      0.2304
WA08       8    0.27500000     0.21876275     0.07734431     0.10000000     0.80000000   EQUAL       1.5880     12.0      0.1383

FOR H0: VARIANCES ARE EQUAL, F'=    72.58 WITH 5 AND 7 DF      PROB > F'= 0.0001
--------------------------------------------------------------------------------------------------------------------------------

VARIABLE: AS

LOC        N          MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES        T       DF  PROB > ITI

WA05       6    0.01400000     0.01885736     0.00769848     0.00200000     0.05000000   UNEQUAL     0.9037      5.9      0.4019
WA08       8    0.00675000     0.00638637     0.00225792     0.00100000     0.02000000   EQUAL       1.0237     12.0      0.3262

FOR H0: VARIANCES ARE EQUAL, F'=     8.72 WITH 5 AND 7 DF      PROB > F'= 0.0129
```

```
                              S T A T I S T I C A L   A N A L Y S I S   S Y S T E M                                        1
                                                                                              15:28 WEDNESDAY, FEBRUARY 28, 1979
                                                        TTEST PROCEDURE

VARIABLE: MOLY

LOC       N            MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM   VARIANCES         T        DF  PROB > |T|

WA05      5      0.02800000      0.01923538      0.00860233      0.01000000      0.06000000   UNEQUAL     -0.1436       8.9      0.8890
WA08      6      0.03000000      0.02683282      0.01095445      0.01000000      0.08000000   EQUAL       -0.1390       9.0      0.8925

FOR HO: VARIANCES ARE EQUAL, F'=    1.95 WITH 5 AND 4 DF      PROB > F'= 0.5386
-----------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: SO4

LOC       N            MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM   VARIANCES         T        DF  PROB > |T|

WA05      6    322.33333333     97.34200875     39.73970866    251.00000000    500.00000000   UNEQUAL     -1.8539       6.7      0.1085
WA08      8    401.87500000     45.75224429     16.17586109    346.00000000    480.00000000   EQUAL       -2.0485      12.0      0.0630

FOR HO: VARIANCES ARE EQUAL, F'=    4.53 WITH 5 AND 7 DF      PROB > F'= 0.0734
-----------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: NA

LOC       N            MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM   VARIANCES         T        DF  PROB > |T|

WA05      6    178.00000000     56.50840645     23.06946033    130.00000000    290.00000000   UNEQUAL      1.2041      11.6      0.2527
WA08      8    139.25000000     63.46821477     22.43940253     88.00000000    290.00000000   EQUAL        1.1827      12.0      0.2598

FOR HO: VARIANCES ARE EQUAL, F'=    1.26 WITH 7 AND 5 DF      PROB > F'= 0.8258
-----------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: NH3

LOC       N            MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM   VARIANCES         T        DF  PROB > |T|

WA05      5      0.24000000      0.26076810      0.11661904      0.10000000      0.70000000   UNEQUAL     -1.3438       6.5      0.2245
WA08      7      1.04000000      1.54462509      0.58381341      0.08000000      3.80000000   EQUAL       -1.1312      10.0      0.2844

FOR HO: VARIANCES ARE EQUAL, F'=   35.09 WITH 6 AND 4 DF      PROB > F'= 0.0041
```

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                        S T A T I S T I C A L   A N A L Y S I S   S Y S T E M     14:04 WEDNESDAY, FEBRUARY 28, 1979

                                                  TTEST PROCEDURE
VARIABLE: SPECCOND

LOC       N          MEAN        STD DEV     STD ERROR      MINIMUM       MAXIMUM     VARIANCES        T       DF  PROB > |T|

WA05      6  1345.16666667  133.49219703   54.49796123  1200.00000000  1521.00000000   UNEQUAL      1.1098     9.7      0.2939
WA08      7  1269.42857143  108.66900377   41.07302274  1100.00000000  1400.00000000   EQUAL        1.1289    11.0      0.2829

FOR H0: VARIANCES ARE EQUAL, F'=    1.51 WITH 5 AND 6 DF     PROB > F'= 0.6263
-----------------------------------------------------------------------------------------------------------------------------

VARIABLE: TDS

LOC       N          MEAN        STD DEV     STD ERROR      MINIMUM       MAXIMUM     VARIANCES        T       DF  PROB > |T|

WA05      5   962.40000000  138.39544790   61.89232586   851.00000000  1200.00000000   UNEQUAL     -0.7115     7.8      0.4974
WA08      5  1029.60000000  159.50956084   71.33484422   880.00000000  1200.00000000   EQUAL       -0.7115     8.0      0.4970

FOR H0: VARIANCES ARE EQUAL, F'=    1.33 WITH 4 AND 4 DF     PROB > F'= 0.7898
```

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                         S T A T I S T I C A L   A N A L Y S I S   S Y S T E M                         1
                                                                                11:35 WEDNESDAY, FEBRUARY 28, 1979
                                              TTEST PROCEDURE

VARIABLE: PH

LOC        N          MEAN         STD DEV       STD ERROR        MINIMUM         MAXIMUM    VARIANCES          T        DF   PROB > |T|

WA03      11    8.12727273      0.33193647      0.10008261     7.50000000      8.40000000    UNEQUAL      -0.3155      20.0       0.7557
WA06      11    8.17272727      0.34377583      0.10365231     7.40000000      8.60000000    EQUAL        -0.3155      20.0       0.7557

FOR H0: VARIANCES ARE EQUAL, F'=     1.07 WITH 10 AND 10 DF      PROB > F'= 0.9139
-------------------------------------------------------------------------------------------------------------------------------------
VARIABLE: B

LOC        N          MEAN         STD DEV       STD ERROR        MINIMUM         MAXIMUM    VARIANCES          T        DF   PROB > |T|

WA03       6    0.16333333      0.26553091      0.10840254     0.01000000      0.70000000    UNEQUAL      -0.9280       7.3       0.3831
WA06       6    0.39000000      0.53617161      0.21889114     0.06000000      1.40000000    EQUAL        -0.9280      10.0       0.3753

FOR H0: VARIANCES ARE EQUAL, F'=     4.08 WITH 5 AND 5 DF      PROB > F'= 0.1491
-------------------------------------------------------------------------------------------------------------------------------------
VARIABLE: F

LOC        N          MEAN         STD DEV       STD ERROR        MINIMUM         MAXIMUM    VARIANCES          T        DF   PROB > |T|

WA03      11    0.50727273      0.46426481      0.13998111     0.30000000      1.90000000    UNEQUAL      -0.1667      20.0       0.8693
WA06      11    0.54000000      0.45633321      0.13758964     0.30000000      1.90000000    EQUAL        -0.1667      20.0       0.8693

FOR H0: VARIANCES ARE EQUAL, F'=     1.04 WITH 10 AND 10 DF      PROB > F'= 0.9576
-------------------------------------------------------------------------------------------------------------------------------------
VARIABLE: AS

LOC        N          MEAN         STD DEV       STD ERROR        MINIMUM         MAXIMUM    VARIANCES          T        DF   PROB > |T|

WA03       9    0.00922222      0.01646039      0.00548680     0.00100000      0.05000000    UNEQUAL       0.0573      16.5       0.9550
WA06      10    0.00880000      0.01554778      0.00491664     0.00100000      0.05000000    EQUAL         0.0575      17.0       0.9548

FOR H0: VARIANCES ARE EQUAL, F'=     1.12 WITH 8 AND 9 DF      PROB > F'= 0.8611
```

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                              S T A T I S T I C A L   A N A L Y S I S   S Y S T E M
                                                                                         15:37 WEDNESDAY, FEBRUARY 28, 1979

                                               TTEST PROCEDURE

VARIABLE: MOLY

LOC        N           MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM   VARIANCES         T       DF   PROB > |T|

WA03       5     0.01740000      0.00581378      0.00260000      0.00700000      0.02000000   UNEQUAL     -3.2497      5.9       0.0177
WA06       5     0.03600000      0.01140175      0.00509902      0.02000000      0.05000000   EQUAL       -3.2497      8.0       0.0117

FOR H0: VARIANCES ARE EQUAL, F'=     3.85 WITH 4 AND 4 DF      PROB > F'= 0.2203
-------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: SO4

LOC        N           MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM   VARIANCES         T       DF   PROB > |T|

WA03      11   360.45454545     18.94393642      5.71181174    330.00000000    400.00000000   UNEQUAL      1.7894     14.2       0.0950
WA06      11   336.27272727     40.62041583     12.24751619    268.00000000    400.00000000   EQUAL        1.7894     20.0       0.0887

FOR H0: VARIANCES ARE EQUAL, F'=     4.60 WITH 10 AND 10 DF      PROB > F'= 0.0242
-------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: NA

LOC        N           MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM   VARIANCES         T       DF   PROB > |T|

WA03      11   136.27272727     37.93702916     11.43844467    120.00000000    250.00000000   UNEQUAL     -3.2347     20.0       0.0042
WA06      11   188.36363636     37.59593789     11.33560178    168.00000000    300.00000000   EQUAL       -3.2347     20.0       0.0042

FOR H0: VARIANCES ARE EQUAL, F'=     1.02 WITH 10 AND 10 DF      PROB > F'= 0.9778
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VARIABLE: NH3

LOC        N           MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM   VARIANCES         T       DF   PROB > |T|

WA03      10     0.07800000      0.06795423      0.02148902      0.01000000      0.20000000   UNEQUAL     -0.7424     12.7       0.4714
WA06      10     0.11600000      0.14690889      0.04645667      0.01000000      0.50000000   EQUAL       -0.7424     18.0       0.4674

FOR H0: VARIANCES ARE EQUAL, F'=     4.67 WITH 9 AND 9 DF      PROB > F'= 0.0312
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                                      S T A T I S T I C A L   A N A L Y S I S   S Y S T E M              14:14 WEDNESDAY, FEBRUARY 28, 1979

                                                              TTEST PROCEDURE

VARIABLE: SPECCOND

LOC       N            MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM   VARIANCES          T        DF   PROB > |T|

WA03     11   1378.09090909    121.07886235     36.50665059   1200.00000000   1559.00000000   UNEQUAL       1.9774      14.0       0.0680
WA08      7   1269.42857143    108.66900377     41.07302274   1100.00000000   1400.00000000   EQUAL         1.9278      16.0       0.0718

FOR H0: VARIANCES ARE EQUAL, F'=    1.24 WITH 10 AND 6 DF      PROB > F'= 0.8241
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VARIABLE: TDS

LOC       N            MEAN         STD DEV       STD ERROR         MINIMUM         MAXIMUM   VARIANCES          T        DF   PROB > |T|

WA03     10    952.30000000     66.08252416     20.89712899    807.00000000   1022.00000000   UNEQUAL      -1.0399       4.7       0.3493
WA08      5   1029.60000000    159.50956084     71.33484422    880.00000000   1200.00000000   EQUAL        -1.3548      13.0       0.1986

FOR H0: VARIANCES ARE EQUAL, F'=    5.83 WITH 4 AND 9 DF      PROB > F'= 0.0270
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                              S T A T I S T I C A L   A N A L Y S I S   S Y S T E M          11:37 WEDNESDAY, FEBRUARY 28, 1979

                                                    TTEST PROCEDURE

VARIABLE: PH

LOC          N          MEAN         STD DEV       STD ERROR        MINIMUM         MAXIMUM     VARIANCES          T        DF    PROB > |T|

WA06        11    8.17272727      0.34377583      0.10365231     7.40000000      8.60000000     UNEQUAL       0.3368      13.5        0.7414
WA08         8    8.11250000      0.41209396      0.14569722     7.60000000      8.70000000     EQUAL         0.3471      17.0        0.7328

FOR H0: VARIANCES ARE EQUAL, F'=     1.44 WITH 7 AND 10 DF      PROB > F'= 0.5819
------------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: B

LOC          N          MEAN         STD DEV       STD ERROR        MINIMUM         MAXIMUM     VARIANCES          T        DF    PROB > |T|

WA06         6    0.39000000      0.53617161      0.21889114     0.06000000      1.40000000     UNEQUAL       0.9406       6.7        0.3797
WA08         7    0.16714286      0.23984122      0.09065146     0.03000000      0.70000000     EQUAL         0.9951      11.0        0.3411

FOR H0: VARIANCES ARE EQUAL, F'=     5.00 WITH 5 AND 6 DF      PROB > F'= 0.0753
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VARIABLE: F

LOC          N          MEAN         STD DEV       STD ERROR        MINIMUM         MAXIMUM     VARIANCES          T        DF    PROB > |T|

WA06        11    0.54000000      0.45633321      0.13758964     0.30000000      1.90000000     UNEQUAL       1.6789      15.2        0.1137
WA08         8    0.27500000      0.21876275      0.07734431     0.10000000      0.80000000     EQUAL         1.5124      17.0        0.1488

FOR H0: VARIANCES ARE EQUAL, F'=     4.35 WITH 10 AND 7 DF      PROB > F'= 0.0634
------------------------------------------------------------------------------------------------------------------------------------------

VARIABLE: AS

LOC          N          MEAN         STD DEV       STD ERROR        MINIMUM         MAXIMUM     VARIANCES          T        DF    PROB > |T|

WA06        10    0.00880000      0.01554778      0.00491664     0.00100000      0.05000000     UNEQUAL       0.3789      12.5        0.7111
WA08         8    0.00675000      0.00638637      0.00225792     0.00100000      0.02000000     EQUAL         0.3485      16.0        0.7320

FOR H0: VARIANCES ARE EQUAL, F'=     5.93 WITH 9 AND 7 DF      PROB > F'= 0.0285
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                                 S T A T I S T I C A L   A N A L Y S I S   S Y S T E M      15:27 WEDNESDAY, FEBRUARY 28, 1979  1

                                                        TTEST PROCEDURE

VARIABLE: MOLY

LOC          N           MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES        T        DF  PROB > |T|

WA06         5     0.03600000     0.01140175     0.00509902     0.02000000     0.05000000   UNEQUAL     0.4966       7.0      0.6347
WA08         6     0.03000000     0.02683282     0.01095445     0.01000000     0.08000000   EQUAL       0.4631       9.0      0.6543

FOR HO: VARIANCES ARE EQUAL, F'=    5.54 WITH 5 AND 4 DF     PROB > F'= 0.1222
---------------------------------------------------------------------------------------------------------------------------------

VARIABLE: SO4

LOC          N           MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES        T        DF  PROB > |T|

WA06        11   336.27272727    40.62041583    12.24751619   268.00000000   400.00000000   UNEQUAL    -3.2333      14.1      0.0060
WA08         8   401.87500000    45.75224429    16.17586109   346.00000000   480.00000000   EQUAL      -3.2981      17.0      0.0042

FOR HO: VARIANCES ARE EQUAL, F'=    1.27 WITH 7 AND 10 DF     PROB > F'= 0.7077
---------------------------------------------------------------------------------------------------------------------------------

VARIABLE: NA

LOC          N           MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES        T        DF  PROB > |T|

WA06        11   188.36363636    37.59593789    11.33560178   168.00000000   300.00000000   UNEQUAL     1.9536      10.5      0.0778
WA08         8   139.25000000    63.46821477    22.43940253    88.00000000   290.00000000   EQUAL       2.1181      17.0      0.0492

FOR HO: VARIANCES ARE EQUAL, F'=    2.85 WITH 7 AND 10 DF     PROB > F'= 0.1303
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VARIABLE: NH3

LOC          N           MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES        T        DF  PROB > |T|

WA06        10     0.11600000     0.14690889     0.04645667     0.01000000     0.50000000   UNEQUAL    -1.5777       6.1      0.1652
WA08         7     1.04000000     1.54462509     0.58381341     0.08000000     3.80000000   EQUAL      -1.9064      15.0      0.0759

FOR HO: VARIANCES ARE EQUAL, F'=  110.55 WITH 6 AND 9 DF     PROB > F'= 0.0001
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                         S T A T I S T I C A L   A N A L Y S I S   S Y S T E M                                            1
                                                                                      14:14 WEDNESDAY, FEBRUARY 28, 1979
                                                        TTEST PROCEDURE

VARIABLE: SPECCOND

LOC          N           MEAN         STD DEV       STD ERROR        MINIMUM         MAXIMUM   VARIANCES        T        DF  PROB > |T|

WA06        11  1481.18181818     90.78195656     27.37178978  1350.00000000   1650.00000000   UNEQUAL     4.2902      11.2      0.0012
WA08         7  1269.42857143    108.66900377     41.07302274  1100.00000000   1400.00000000   EQUAL       4.4748      16.0      0.0004

FOR H0: VARIANCES ARE EQUAL, F'=    1.43 WITH 6 AND 10 DF      PROB > F'= 0.5859
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VARIABLE: TDS

LOC          N           MEAN         STD DEV       STD ERROR        MINIMUM         MAXIMUM   VARIANCES        T        DF  PROB > |T|

WA06        10  1058.40000000     96.52426293     30.52365203   912.00000000   1200.00000000   UNEQUAL     0.3712       5.5      0.7244
WA08         5  1029.60000000    159.50956084     71.33484422   880.00000000   1200.00000000   EQUAL       0.4400      13.0      0.6671

FOR H0: VARIANCES ARE EQUAL, F'=    2.73 WITH 4 AND 9 DF      PROB > F'= 0.1941
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                        S T A T I S T I C A L   A N A L Y S I S   S Y S T E M            11:42 WEDNESDAY, FEBRUARY 28, 1978

                                                  TTEST PROCEDURE
VARIABLE: PH

LOC        N         MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES         T        DF   PROB > |T|

WA03      11   8.12727273     0.33193647     0.10008261     7.50000000     8.40000000   UNEQUAL      0.0836      13.1       0.9347
WA08       8   8.11250000     0.41209396     0.14569722     7.60000000     8.70000000   EQUAL        0.0866      17.0       0.9320

FOR H0: VARIANCES ARE EQUAL, F'=     1.54 WITH 7 AND 10 DF      PROB > F'= 0.5160
---------------------------------------------------------------------------------------------------------------------------------
VARIABLE: B

LOC        N         MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES         T        DF   PROB > |T|

WA03       6   0.16333333     0.26553091     0.10840254     0.01000000     0.70000000   UNEQUAL     -0.0270      10.3       0.9790
WA08       7   0.16714286     0.23984122     0.09065146     0.03000000     0.70000000   EQUAL       -0.0272      11.0       0.9788

FOR H0: VARIANCES ARE EQUAL, F'=     1.23 WITH 5 AND 6 DF      PROB > F'= 0.7994
---------------------------------------------------------------------------------------------------------------------------------
VARIABLE: F

LOC        N         MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES         T        DF   PROB > |T|

WA03      11   0.50727273     0.46426481     0.13998111     0.30000000     1.90000000   UNEQUAL      1.4524      15.0       0.1670
WA08       8   0.27500000     0.21876275     0.07734431     0.10000000     0.80000000   EQUAL        1.3060      17.0       0.2089

FOR H0: VARIANCES ARE EQUAL, F'=     4.50 WITH 10 AND 7 DF      PROB > F'= 0.0579
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VARIABLE: AS

LOC        N         MEAN        STD DEV      STD ERROR        MINIMUM        MAXIMUM   VARIANCES         T        DF   PROB > |T|

WA03       9   0.00922222     0.01646039     0.00548680     0.00100000     0.05000000   UNEQUAL      0.4167      10.6       0.6853
WA08       8   0.00675000     0.00638637     0.00225792     0.00100000     0.02000000   EQUAL        0.3979      15.0       0.6963

FOR H0: VARIANCES ARE EQUAL, F'=     6.64 WITH 8 AND 7 DF      PROB > F'= 0.0217
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                                   S T A T I S T I C A L   A N A L Y S I S   S Y S T E M                                     1
                                                                                               15:28 WEDNESDAY, FEBRUARY 28, 1979
                                                        TTEST PROCEDURE
VARIABLE: MOLY

LOC         N             MEAN          STD DEV       STD ERROR         MINIMUM         MAXIMUM   VARIANCES         T        DF   PROB > |T|

WA03        5       0.01740000       0.00581378      0.00260000      0.00700000      0.02000000   UNEQUAL     -1.1191       5.6       0.3095
WA08        6       0.03000000       0.02683282      0.01095445      0.01000000      0.08000000   EQUAL       -1.0214       9.0       0.3337

FOR H0: VARIANCES ARE EQUAL, F'=   21.30 WITH 5 AND 4 DF     PROB > F'= 0.0111
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VARIABLE: SO4

LOC         N             MEAN          STD DEV       STD ERROR         MINIMUM         MAXIMUM   VARIANCES         T        DF   PROB > |T|

WA03       11     360.45454545      18.94393642      5.71181174    330.00000000    400.00000000   UNEQUAL     -2.4145       8.8       0.0397
WA08        8     401.87500000      45.75224429     16.17586109    346.00000000    480.00000000   EQUAL       -2.7213      17.0       0.0145

FOR H0: VARIANCES ARE EQUAL, F'=    5.83 WITH 7 AND 10 DF     PROB > F'= 0.0133
-------------------------------------------------------------------------------------------------------------------------------------
VARIABLE: NA

LOC         N             MEAN          STD DEV       STD ERROR         MINIMUM         MAXIMUM   VARIANCES         T        DF   PROB > |T|

WA03       11     136.27272727      37.93702916     11.43844467    120.00000000    250.00000000   UNEQUAL     -0.1182      10.6       0.9081
WA08        8     139.25000000      63.46821477     22.43940253     88.00000000    290.00000000   EQUAL       -0.1280      17.0       0.8996

FOR H0: VARIANCES ARE EQUAL, F'=    2.80 WITH 7 AND 10 DF     PROB > F'= 0.1368
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VARIABLE: NH3

LOC         N             MEAN          STD DEV       STD ERROR         MINIMUM         MAXIMUM   VARIANCES         T        DF   PROB > |T|

WA03       10       0.07800000       0.06795423      0.02148902      0.01000000      0.20000000   UNEQUAL     -1.6467       6.0       0.1506
WA08        7       1.04000000       1.54462509      0.58381341      0.08000000      3.80000000   EQUAL       -1.9953      15.0       0.0645

FOR H0: VARIANCES ARE EQUAL, F'=  516.67 WITH 6 AND 9 DF     PROB > F'= 0.0001
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                                    S T A T I S T I C A L   A N A L Y S I S   S Y S T E M                                   1
                                                                                                14:15 WEDNESDAY, FEBRUARY 28, 1979
                                                     TTEST PROCEDURE

VARIABLE: SPECCOND

LOC         N            MEAN          STD DEV        STD ERROR          MINIMUM           MAXIMUM    VARIANCES          T        DF   PROB > |T|

WA03       11   1378.09090909     121.07886235      36.50665059    1200.00000000     1559.00000000    UNEQUAL      -2.2594      18.5       0.0361
WA06       11   1481.18181818      90.78195656      27.37178978    1350.00000000     1650.00000000    EQUAL        -2.2594      20.0       0.0352

FOR H0: VARIANCES ARE EQUAL, F'=     1.78 WITH 10 AND 10 DF     PROB > F'= 0.3776
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VARIABLE: TDS

LOC         N            MEAN          STD DEV        STD ERROR          MINIMUM           MAXIMUM    VARIANCES          T        DF   PROB > |T|

WA03       10    952.30000000      66.08252416      20.89712899     807.00000000     1022.00000000    UNEQUAL      -2.8682      15.9       0.0112
WA06       10   1058.40000000      96.52426293      30.52365203     912.00000000     1200.00000000    EQUAL        -2.8682      18.0       0.0102

FOR H0: VARIANCES ARE EQUAL, F'=     2.13 WITH 9 AND 9 DF     PROB > F'= 0.2743
```

APPENDIX A5.3.2

This Appendix consists of two parts:

A5.3.2A - Summary Tables for Ground Water Quality Analyses of Variance.

A5.3.2B - Potentiometric Surface Maps - Upper Aquifer (1976-1978)

APPENDIX A5.3.2A

Summary Tables for Ground Water Quality Analyses of Variance

List of Tables Appearing in Appendix A5.3.2A

TABLE A5.3.2A-1 GROUND WATER QUALITY ANALYSIS OF VARIANCE

SPECIFIC CONDUCTANCE

	UPC_2					LPC_3					
	SG9=2	CB-2	SG11#3	AT-1C#3	CB-4	AT-1C#2	SG6#2	SG10R	SG11=2	AT-1C#1	N
1974	1600	1600	NM	1200	800	1400	NM	NM	NM	1400	8000
1975	1900	1600	1800	1300	800	1200	1250	NM	1200	1250	8050
1976	1661	1583	1890	1497.5	890	1289.5	1420.5	4795	1287	1357.5	8278.5
1977	2000	1550	1100	NM	700	NM		NM		1250	
N:	5161	4783		3997.5	2490	3889.5				4007.5	24328.5

ANOVA

Source	SS	DF	MS	F
Years	7348.59	2	3674.3	0.29
Wells (Depth)	1411799.14	5	282359.83	22.34**
Error	126389.89	10	12638.99	
TOTAL	1545537.62	17		

** Significant at 95% level of confidence
NM Not Monitored

TABLE A5.3.2A-2 GROUND WATER QUALITY ANALYSIS OF VARIANCE

BORON (B)

	UPC_2					LPC_3					
	SG9#2	CB-2	SG11#3	AT-1C#3	CB-4	AT-1C#2	SG6#2	SG10R	SG11#2	AT-1C#1	N
1974	1.50	2.90	NM	1.30	2.80	1.40	NM	NM	NM	1.10	11.0
1975	.70	.85	1.70	.23	.25	.72	.55	NM	1.90	.51	3.26
1976	.05	.10	.60	.20	.07	.10	.20	.60	.30	.05	0.57
1977	.04	.09	.65	NM	.22	NM		NM		.70	
N:	2.25	3.85		1.73	3.12	2.22				1.66	14.83

ANOVA

Source	SS	DF	MS	F
Years	9.77	2	4.89	20.97**
Wells (Depth)	1.21	5	0.24	1.04
Error	2.33	10	0.23	
TOTAL	13.32	17		

** Significant at 95% level of confidence
NM Not Monitored

TABLE A5.3.2A-3 GROUND WATER QUALITY ANALYSIS OF VARIANCE

Aluminum (Al)

	UPC_2					LPC_3					
	SG9#2	CB-2	SG11#3	AT-1C#3	CB-4	AT-1C#2	SG6#2	SG10R	SG11=2	AT-1C#1	N
1974	.700	NM	NM	.900	NM	.500	NM	NM	NM	.900	3.0
1975	.175	.500	.220	.075	.400	.250	.100	NM	.240	.065	0.565
1976	.018	.030	.030	.020	.040	.040	.025	.030	.070	1.000	1.078
1977	.300	.400	.500	NM	.200	NM		NM		.300	
N:	0.893			0.995		0.790				1.965	4.643

ANOVA

Source	SS	DF	MS	F
Years	0.824	2	0.412	4.49
Wells (Depth)	0.295	3	0.098	1.07
Error	0.551	6	0.092	
TOTAL	1.669	11		

NM Not Monitored

TABLE A5.3.2A-4 GROUND WATER QUALITY ANALYSIS OF VARIANCE

Potassium (K)

	UPC_2					LPC_3					
	SG9#2	CB-2	SG11#3	AT-1C#3	CB-4	AT-1C#2	SG6#2	SG10R	SG11#2	AT-1C#1	N
1974	5.0	3.0	NM	4.0	1.0	6.0	NM	NM	NM	NM	19
1975	5.0	4.5	8.0	2.5	1.0	3.0	8.0	NM	3.5	7.5	16
1976	2.4	2.0	5.0	2.3	0.7	3.1	2.3	10.6	3.0	8.3	10.5
1977	2.1	4.5	2.9	NM	0.8	NM		NM		15.0	
N:	12.4	9.5		8.8	2.7	12.1					45.5

ANOVA

Source	SS	DF	MS	F
Years	7.43	2	3.72	3.80
Wells (Depth)	20.37	4	5.09	5.20**
Error	7.83	8	0.98	
TOTAL	35.63	14		

** Significant at 95% level of confidence
NM Not Monitored

TABLE A5.3.2A-5 GROUND WATER QUALITY ANALYSIS OF VARIANCE

Total Dissolved Solids (TDS)

	UPC_2					LPC_3					
	SG9÷2	CB-2	SG11#3	AT-1C#3	CB-4	AT-1C#2	SG6#2	SG10R	SG11=2	AT-1C#1	N
1974	1300	1000	NM	750	520	890	NM	NM	NM	1200	5660
1975	1350	990	1250	900	545	740	820	NM	790	790	5315
1976	1354.5	1025	1164	945	557	746	566	2651.5	726	804.5	5432
1977	*	*	*	*	*	*	*	*	*	*	
N:	4004.5	3015		2595	1622	*				2794.5	

ANOVA

Source	SS	DF	MS	F
Years	10261.0	2	5130.5	0.38
Wells (Depth)	1026939.67	5	205387.93	15.05**
Error	136449.33	10	13644.93	
TOTAL	1173650.00	17		

* Monitoring of parameter discontinued in 1977.
** Significant at 95% level of confidence
NM Not Monitored

TABLE A5.3.2A-6 GROUND WATER QUALITY ANALYSIS OF VARIANCE

Calcium (Ca)

	UPC$_2$					LPC$_3$					
	SG9#2	CB-2	SG11#3	AT-1C#3	CB-4	AT-1C#2	SG6#2	SG10R	SG11#2	AT-1C#1	N
1974	117.0	6.0	NM	15.0	22.0	28.0	NM	NM	NM	4.0	192.0
1975	80.5	4.0	19.5	47.5	21.5	6.5	8.0	NM	10.0	4.5	164.5
1976	96.0	6.0	43.0	41.0	24.0	6.1	4.8	171.5	7.0	4.9	178.0
1977	52.0	8.7	6.3	NM	23.0	NM		NM		5.0	
N:	293.5	16.0		103.5	67.5	40.6				13.4	534.5

ANOVA

Source	SS	DF	MS	F
Years	63.03	2	31.52	.21
Wells (Depth)	18626.54	5	3725.31	24.51**
Error	1520.22	10	152.0	
TOTAL	20209.79	17		

** Significant at 95% level of confidence

NM Not Monitored

TABLE A5.3.2A-7 GROUND WATER QUALITY ANALYSIS OF VARIANCE

Sodium (Na)

	UPC_2					LPC_3					
	SG9#2	CB-2	SG11#3	AT-1C#3	CB-4	AT-1C#2	SG6#2	SG10R	SG11#2	AT-1C#1	N
1974	270	380	NM	220	130	230	NM	NM	NM	520	1750
1975	215	360	380	220	145	300	310	NM	305	325	1565
1976	197	367	384	214	140	307	231	645	295	333	1558
1977	180	340	280	NM	135	NM		NM		330	
N:	682	1107		654	415	837				1178	4873

ANOVA

Source	SS	DF	MS	F
Years	3952.11	2	1976.06	0.72
Wells (Depth)	140359.61	5	28071.92	10.30**
Error	27265.89	10	2726.59	
TOTAL	171577.61	17		

** Significant at 95% level of confidence
NM Not Monitored

TABLE A5.3.2A-8 GROUND WATER QUALITY ANALYSIS OF VARIANCE

Ammonia (NH_3)

	UPC_2					LPC_3					
	SG9#2	CB-2	SG11#3	AT-1C#3	CB-4	AT-1C#2	SG6#2	SG10R	SG11=2	AT-1C#1	N
1974	.20	.50	NM	.20	.40	.40	NM	NM	NM	.10	1.8
1975	.65	.55	1.35	.95	.50	.50	2.15	NM	.85	.80	3.95
1976	.71	.19	2.48	1.01	.14	1.58	1.88	2.20	1.15	1.85	5.48
1977	*	*	*	*	*	*	*	*	*	*	
N:	1.56	1.24		2.16	1.04	2.48				2.75	11.23

ANOVA

Source	SS	DF	MS	F
Years	1.14	2	0.57	2.88
Wells (Depth)	0.80	5	0.16	0.81
Error	1.98	10	0.20	
TOTAL	3.92	17		

* Monitoring of parameter discontinued in 1977
NM Not Monitored

TABLE A5.3.2A-9 GROUND WATER QUALITY ANALYSIS OF VARIANCE

Magnesium (Mg)

	UPC$_2$					LPC$_3$					
	SG9#2	CB-2	SG11#3	AT-1C#3	CB-4	AT-1C#2	SG6#2	SG10R	SG11#2	AT-1C#1	N
1974	100.0	4.0	NM	23.0	23.0	29.0	NM	NM	NM	4.0	183
1975	145.0	3.5	60.5	49.5	26.0	7.0	11.5	NM	11.5	3.5	234.5
1976	131.0	4.0	57.0	47.5	26.0	4.5	2.9	110.5	6.0	3.3	216.3
1977	127.0	4.1	4.8	NM	22.0	NM		NM		3.0	
N:	376	11.5		120	75	40.5				10.8	623.8

ANOVA

Source	SS	DF	MS	F
Years	227.35	2	13.68	0.69
Wells (Depth)	32113.24	5	6422.65	39.19**
Error	1638.74	10	163.87	
TOTAL	33979.34	17		

** Significant at 95% confidence level
NM Not Monitored

APPENDIX A5.3.2B

Potentiometric Surface Maps - Upper Aquifer

(1976-1978)

List of Figures Appearing in Appendix A5.3.2B

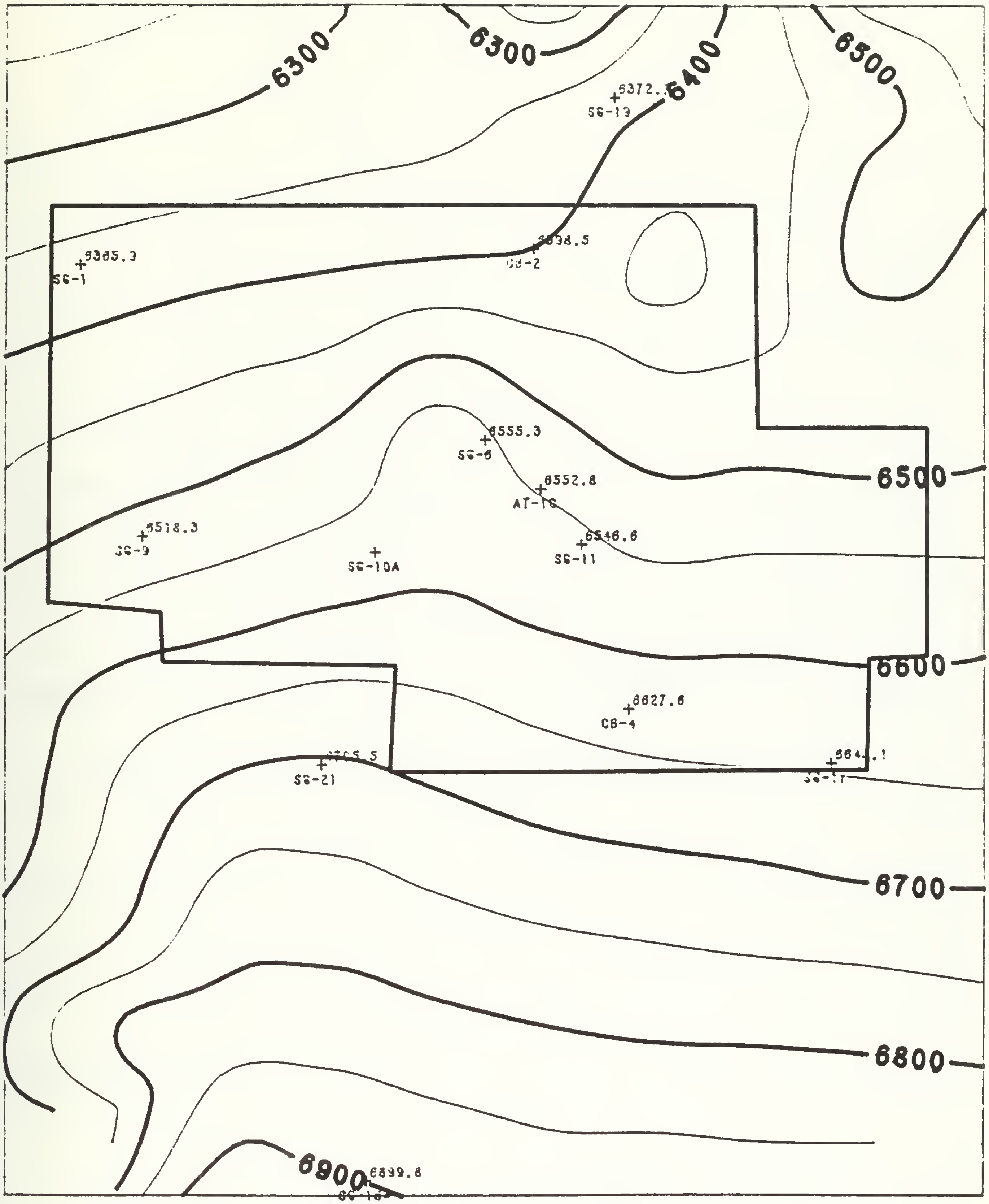


FIGURE A5.3.2B-1 Potentiometric Surface Map - Upper Aquifer, December 1976

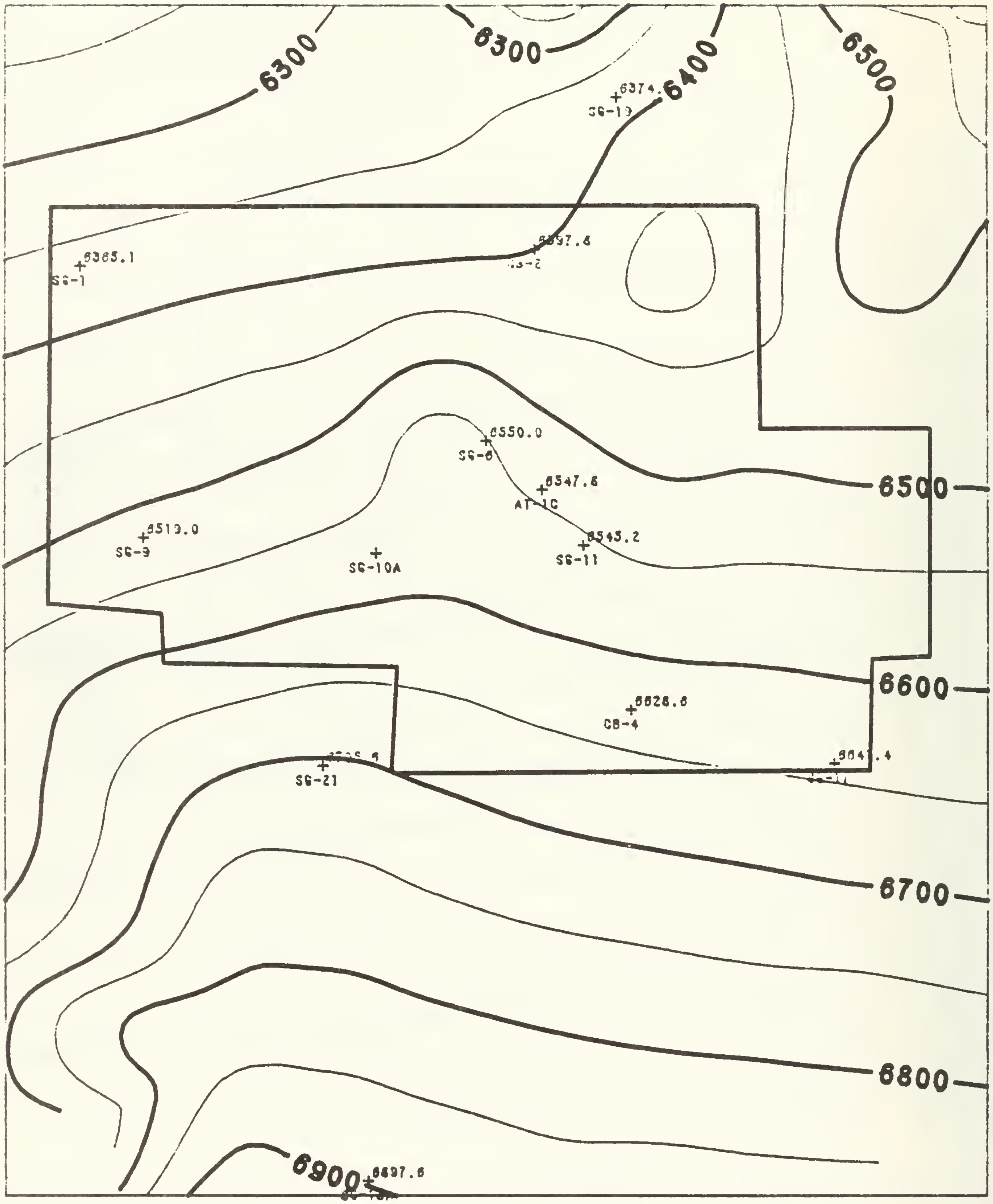


FIGURE A5.3.2B-2 Potentiometric Surface Map - Upper Aquifer, January 1977

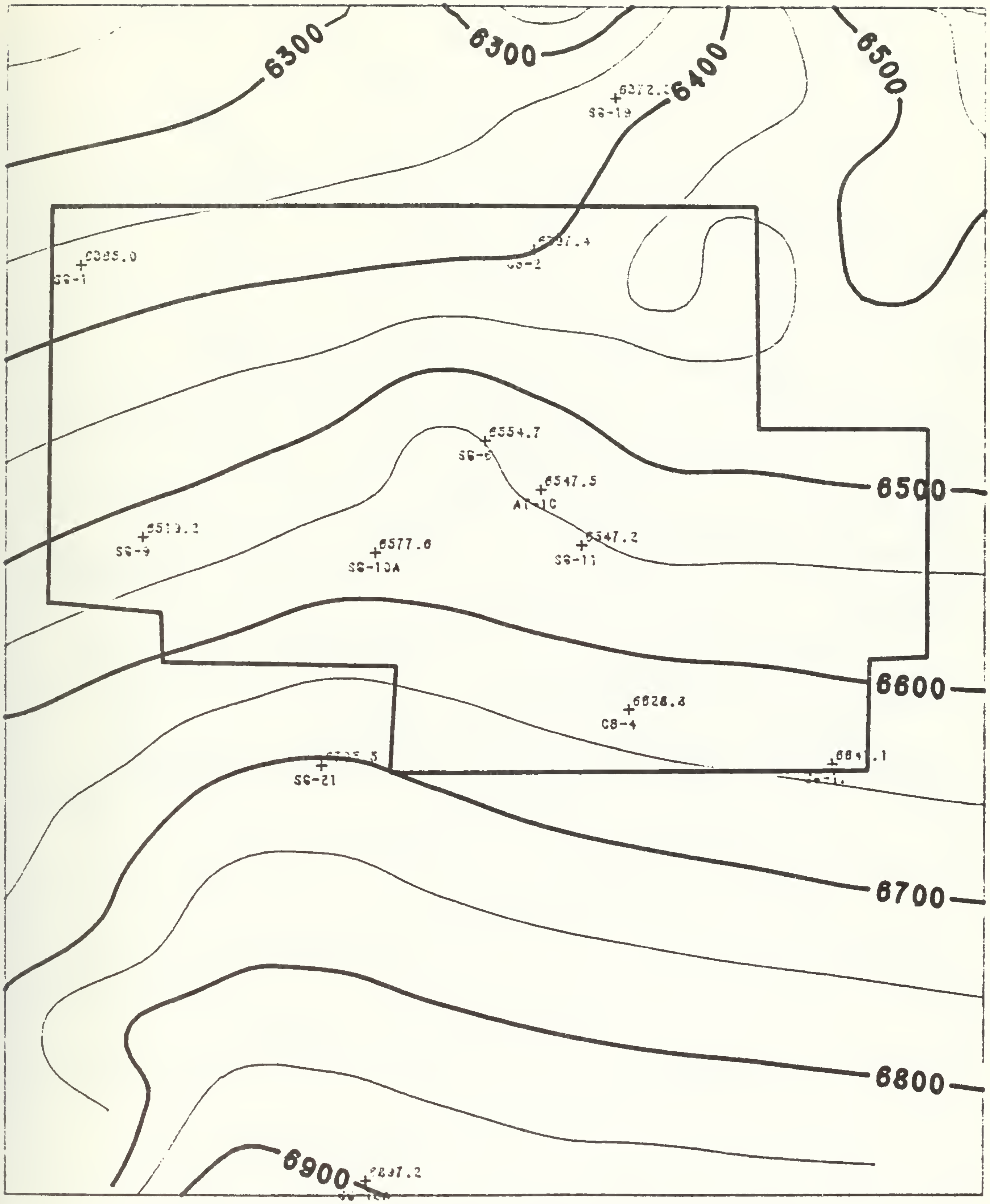


FIGURE A5.3.2B-3 Potentiometric Surface Map - Upper Aquifer, February 1977

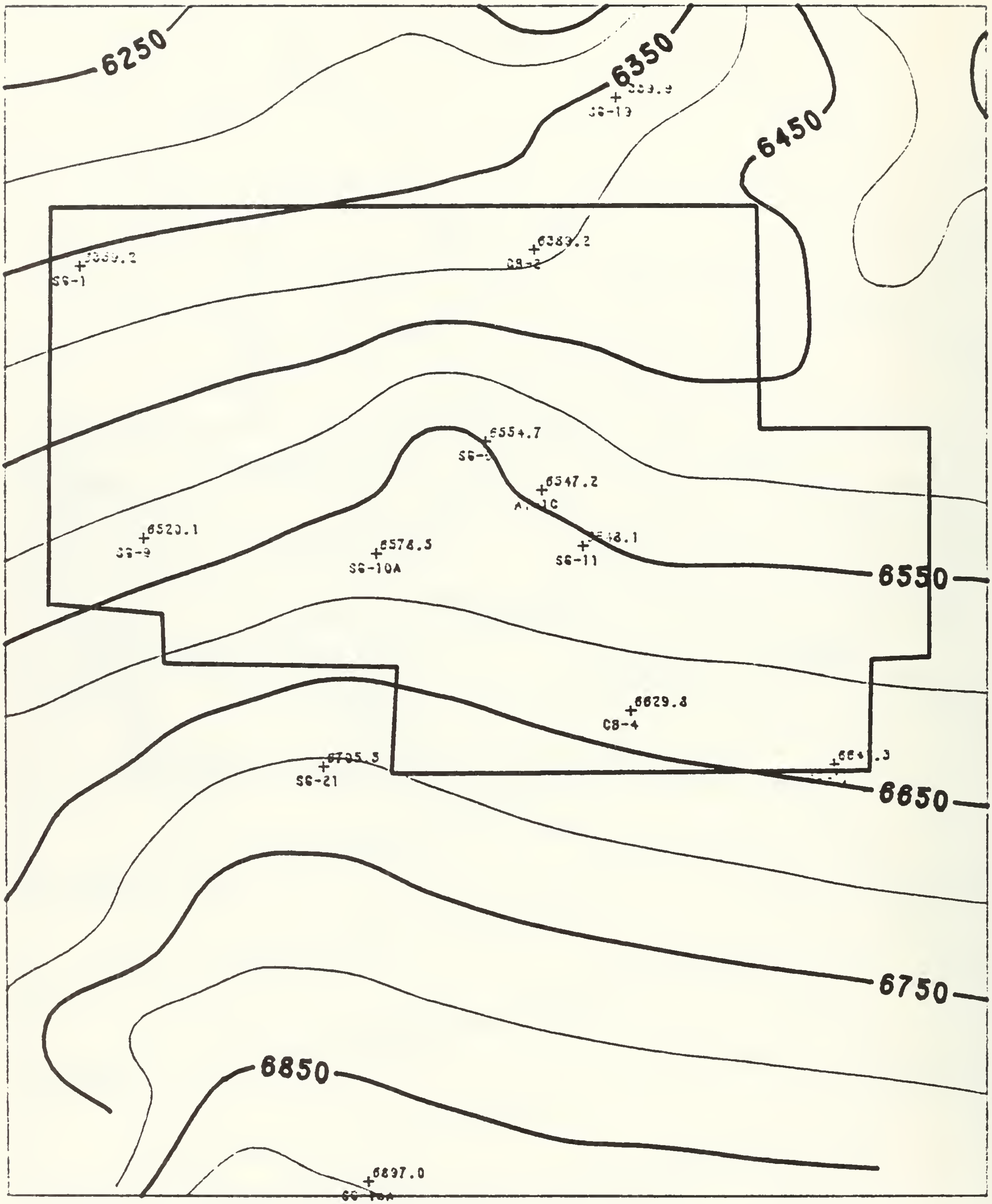


FIGURE A5.3.2B-4 Potentiometric Surface Map - Upper Aquifer, March 1977

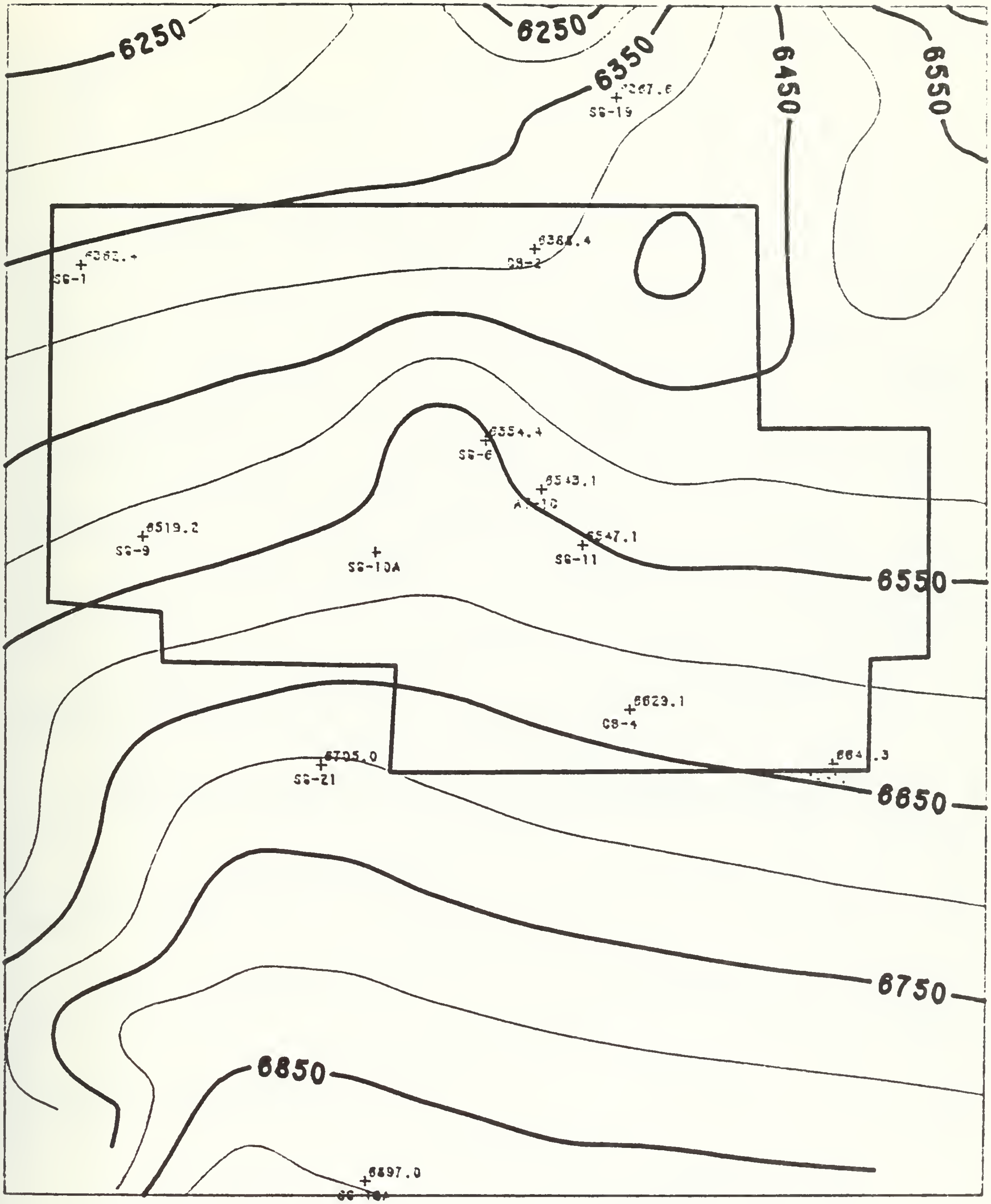


FIGURE A5.3.2B-5 Potentiometric Surface Map - Upper Aquifer, April 1977

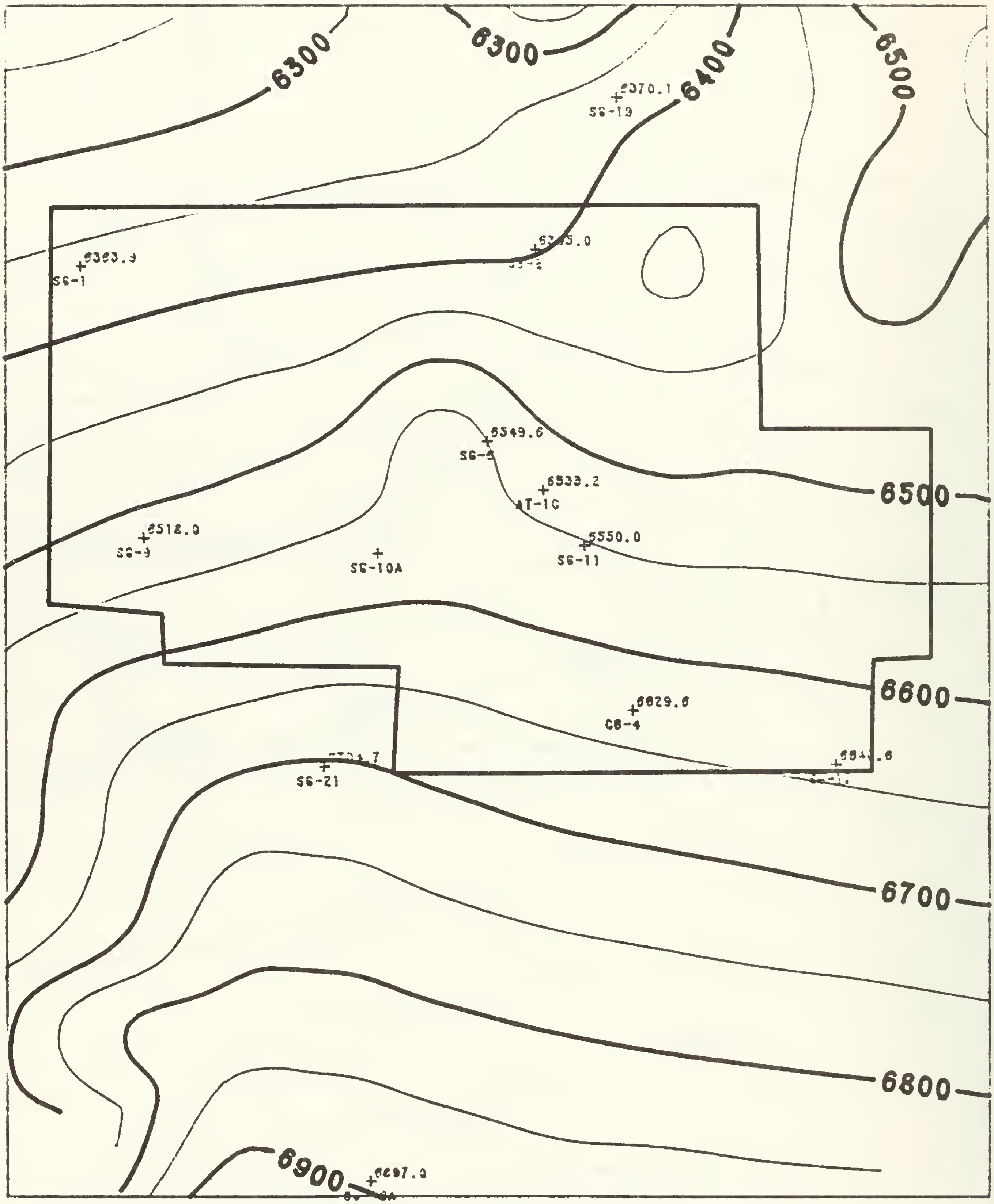


FIGURE A5.3.2B-6 Potentiometric Surface Map - Upper Aquifer, May 1977

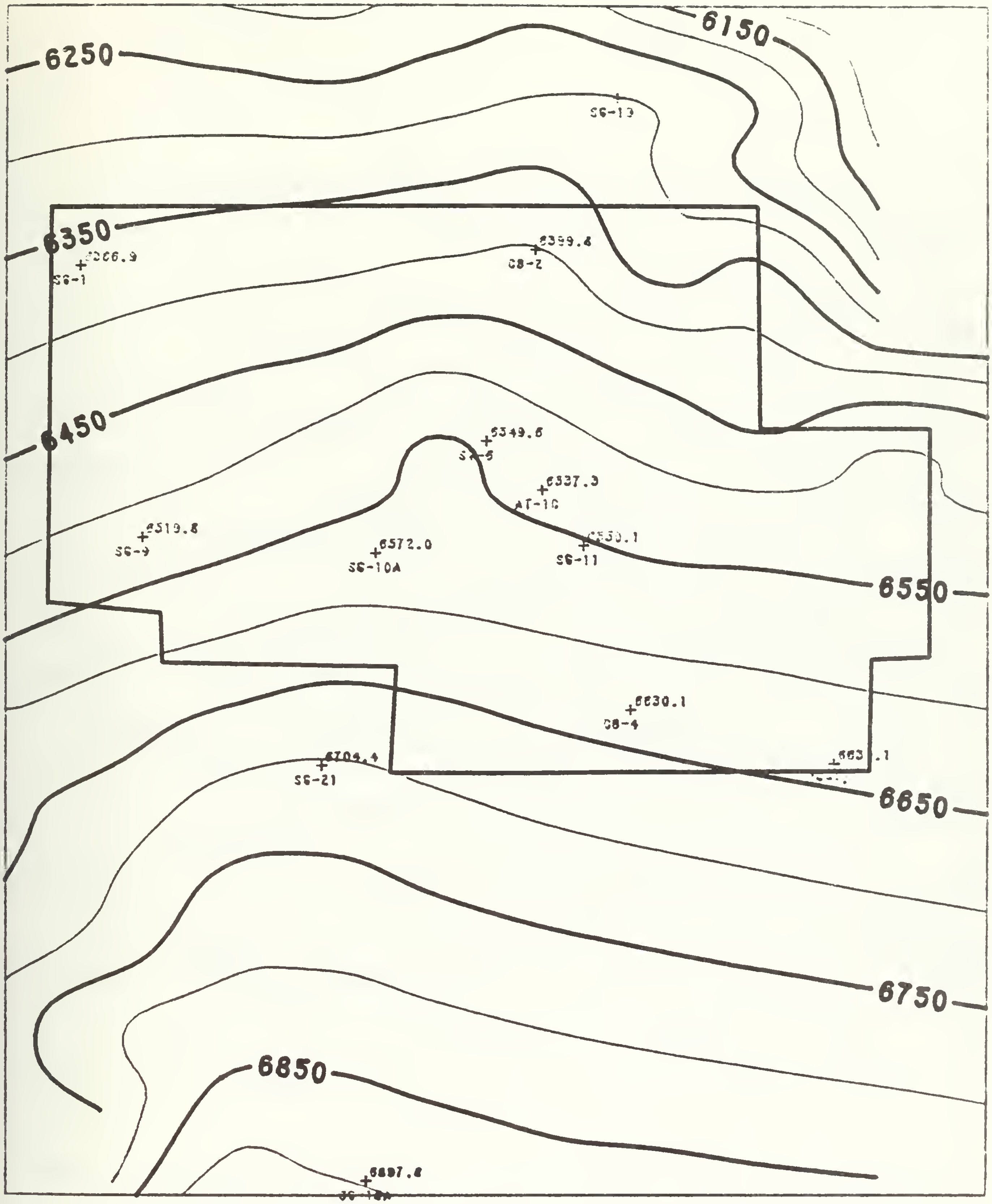


FIGURE A5.3.2B-7 Potentiometric Surface Map - Upper Aquifer, August 1977

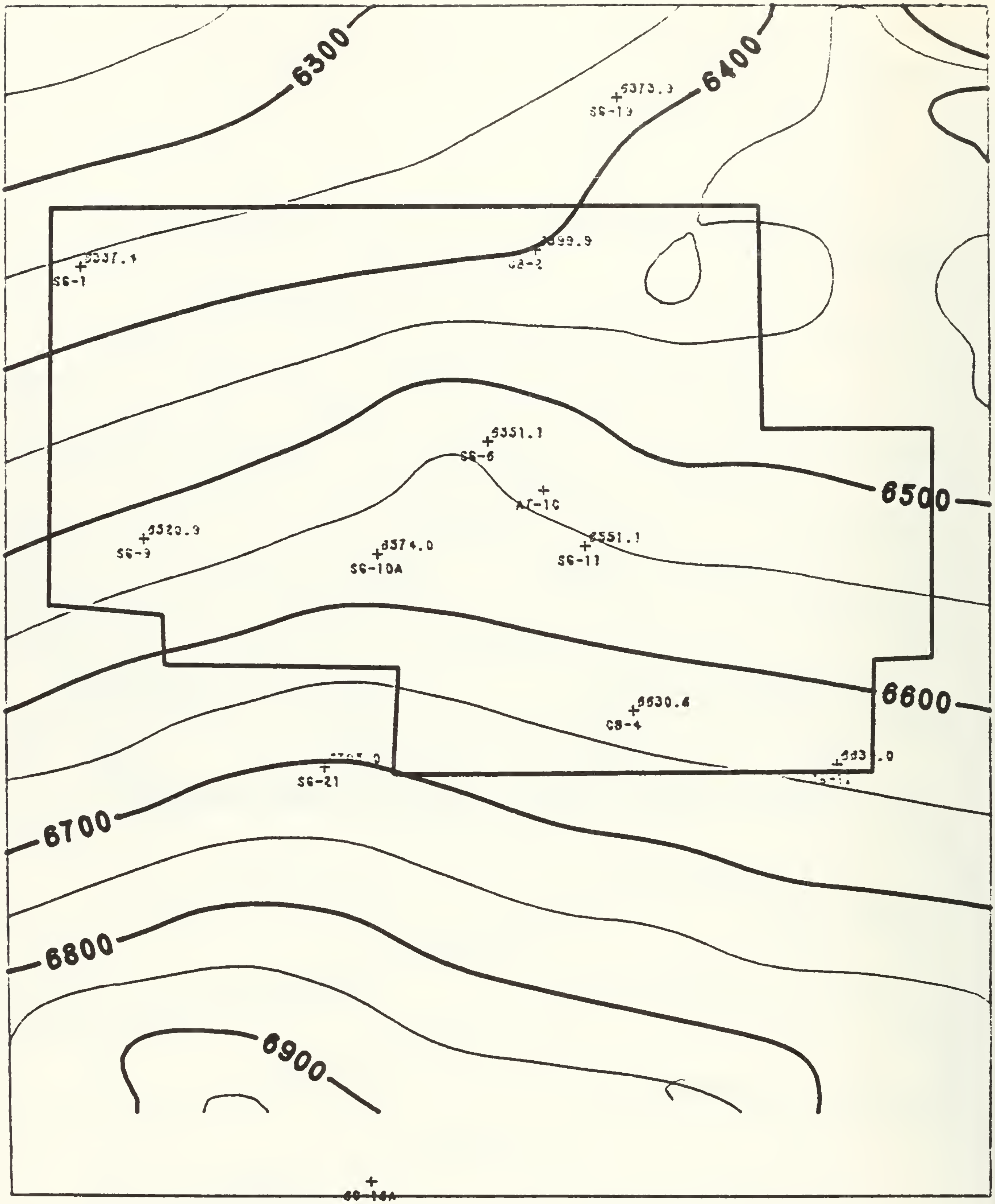


FIGURE A5.3.2B-8 Potentiometric Surface Map - Upper Aquifer, September 1977

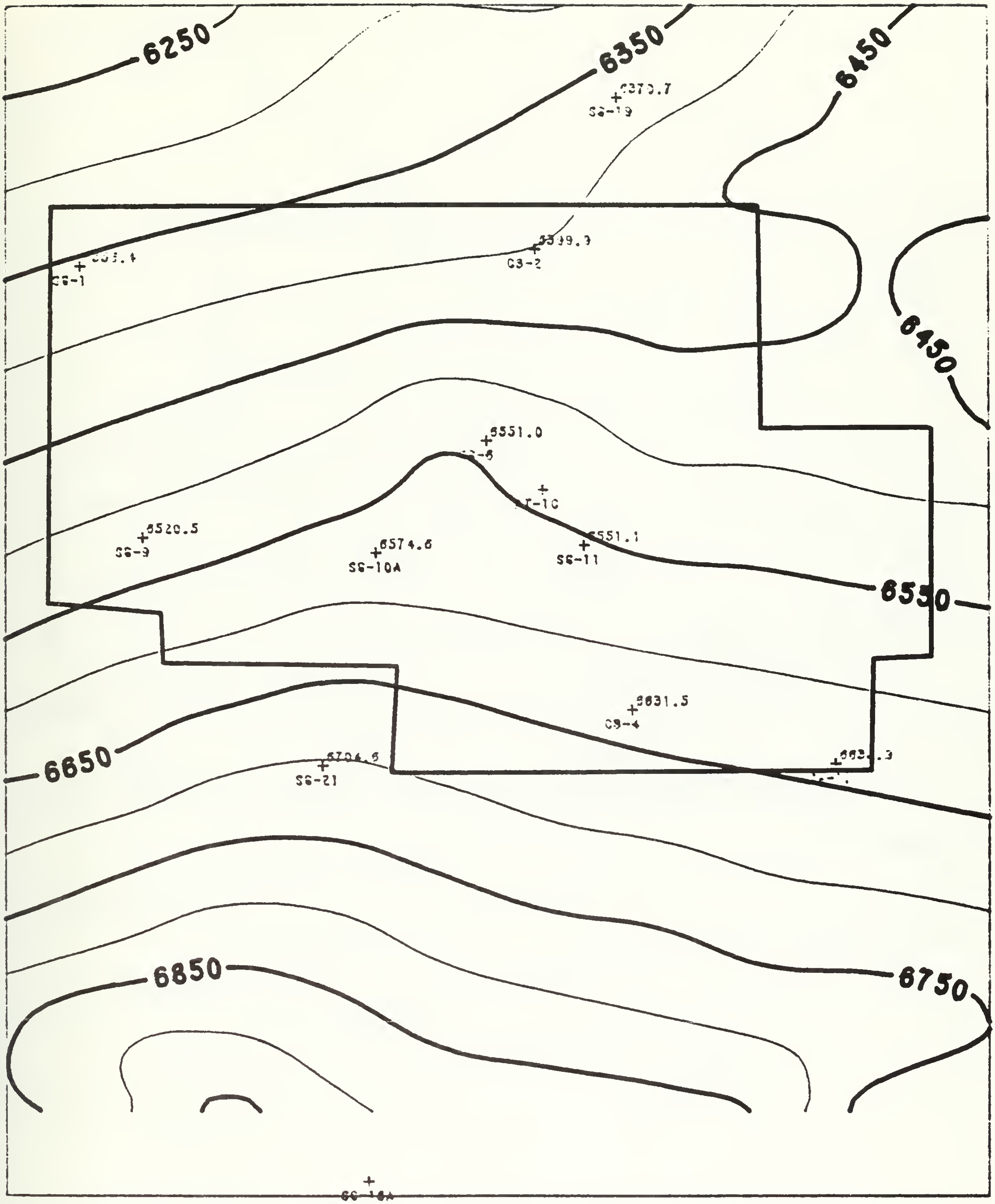


FIGURE A5.3.2B-9 Potentiometric Surface Map - Upper Aquifer, October 1977

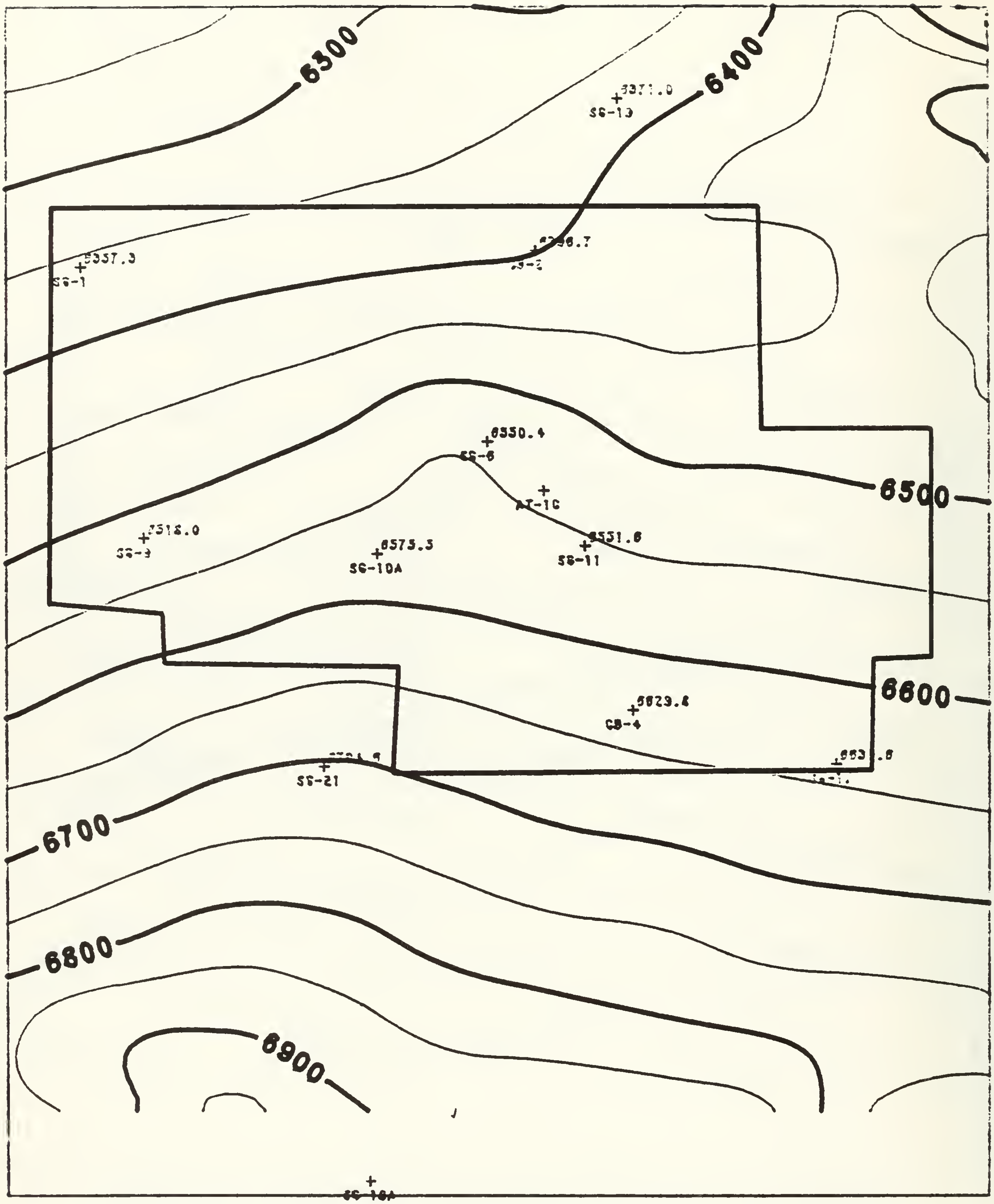


FIGURE A5.3.2B-10 Potentiometric Surface Map - Upper Aquifer, December 1977

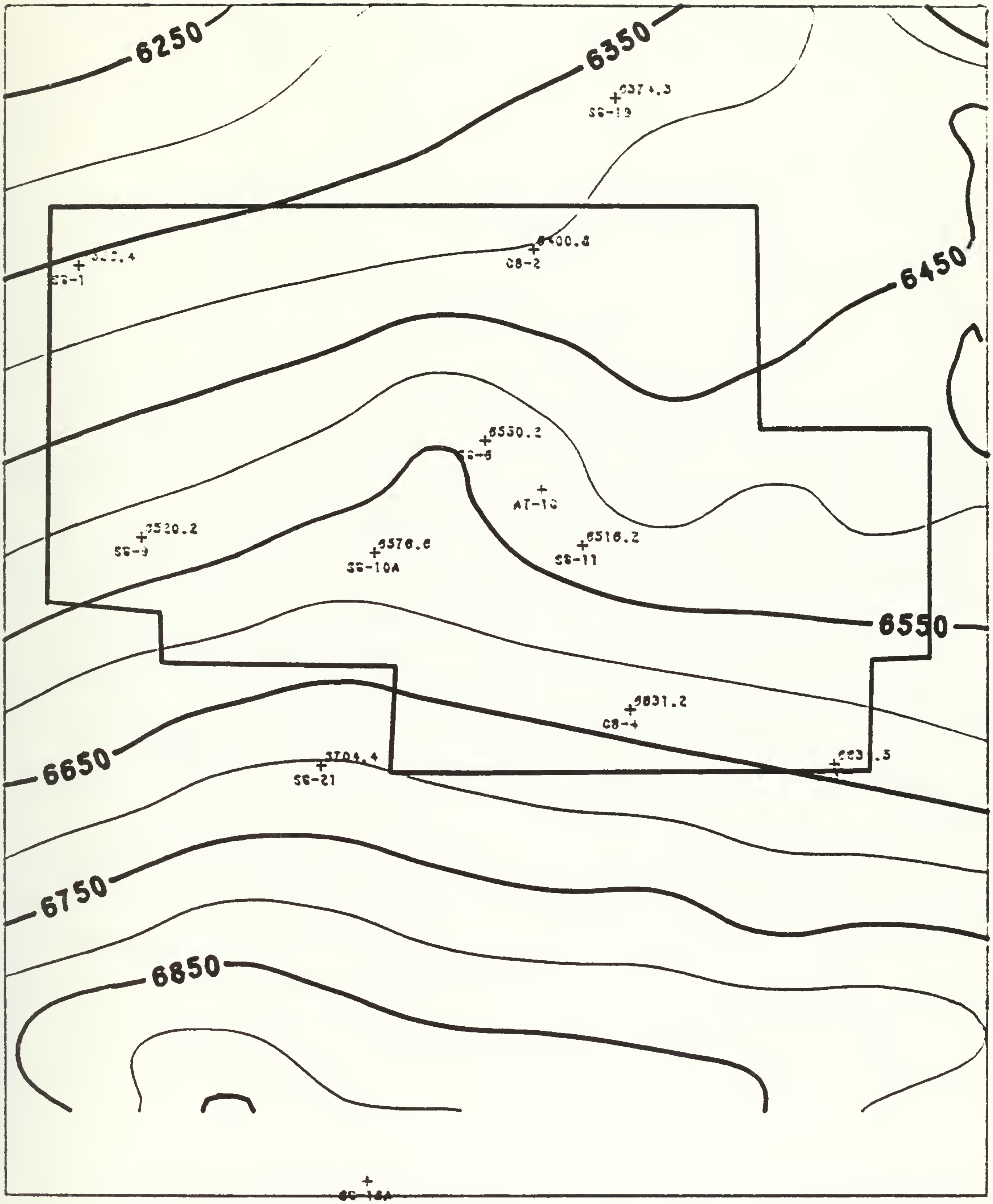


FIGURE A5.3.2B-11 Potentiometric Surface Map - Upper Aquifer, April 1978

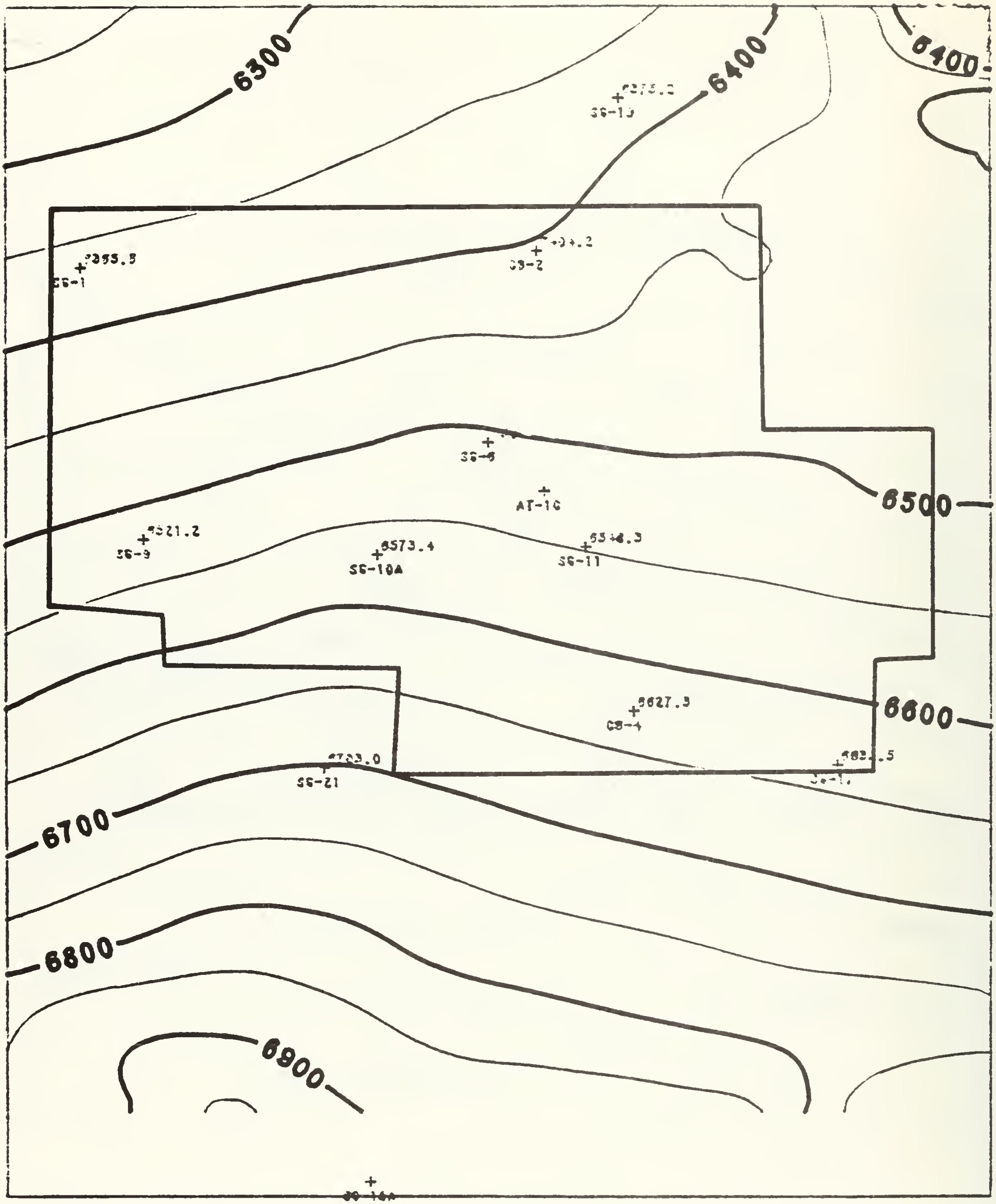


FIGURE A5.3.2B-12 Potentiometric Surface Map - Upper Aquifer, May 1978

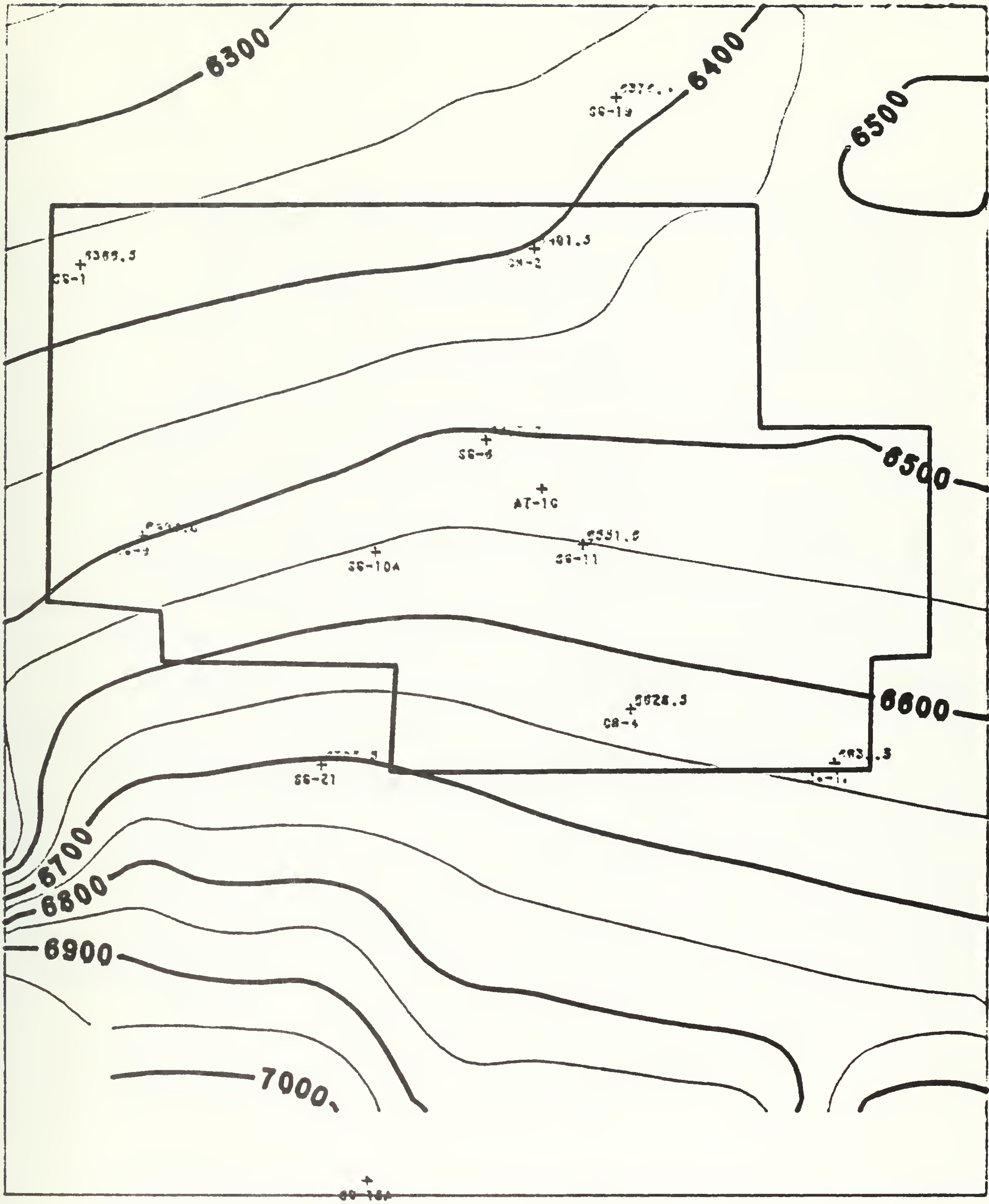


FIGURE A5.3.2B-13 Potentiometric Surface Map - Upper Aquifer, July 1978

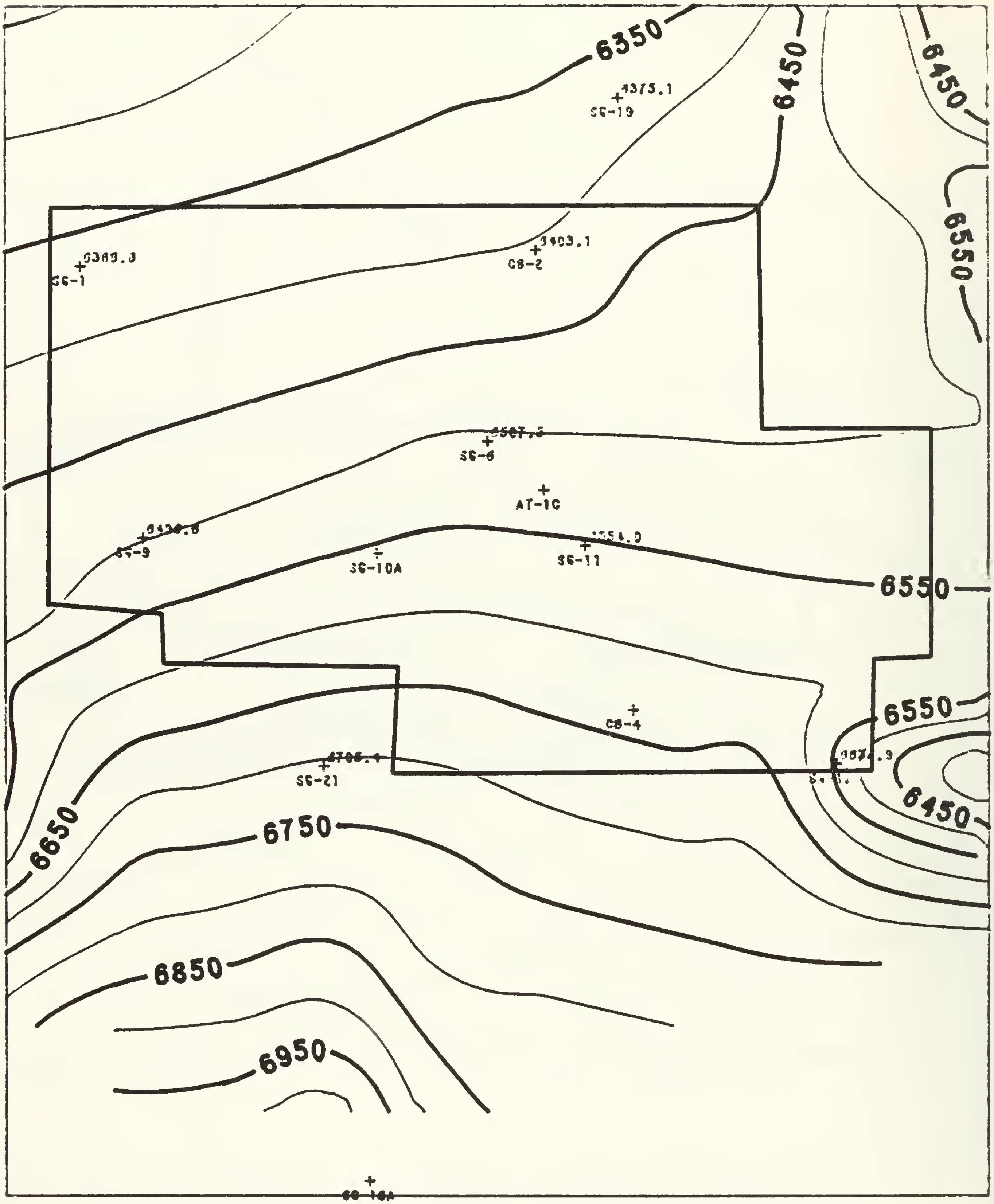


FIGURE A5.3.2B-14 Potentiometric Surface Map - Upper Aquifer, September 1978

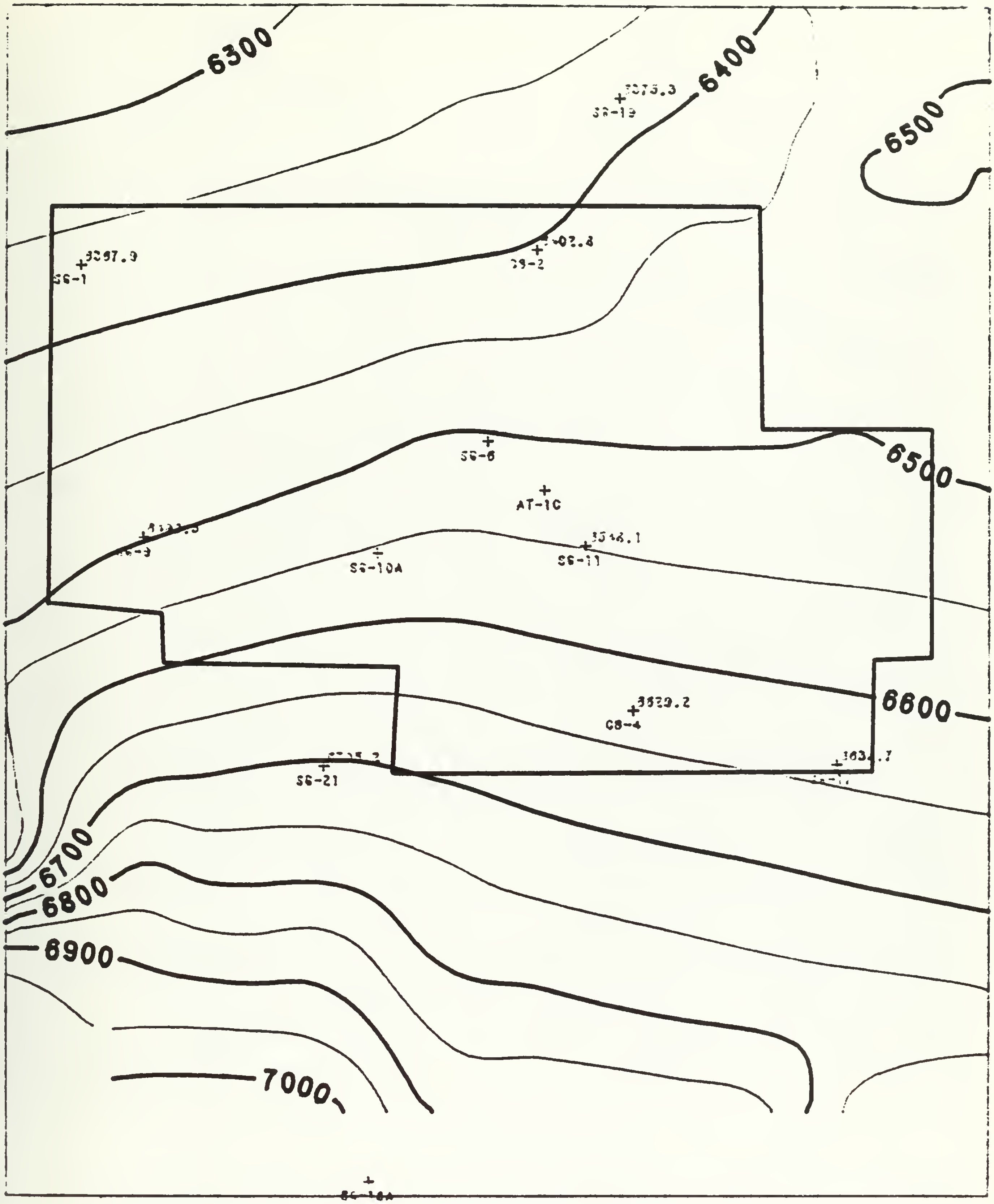


FIGURE A5.3.2B-15 Potentiometric Surface Map - Upper Aquifer, October 1978

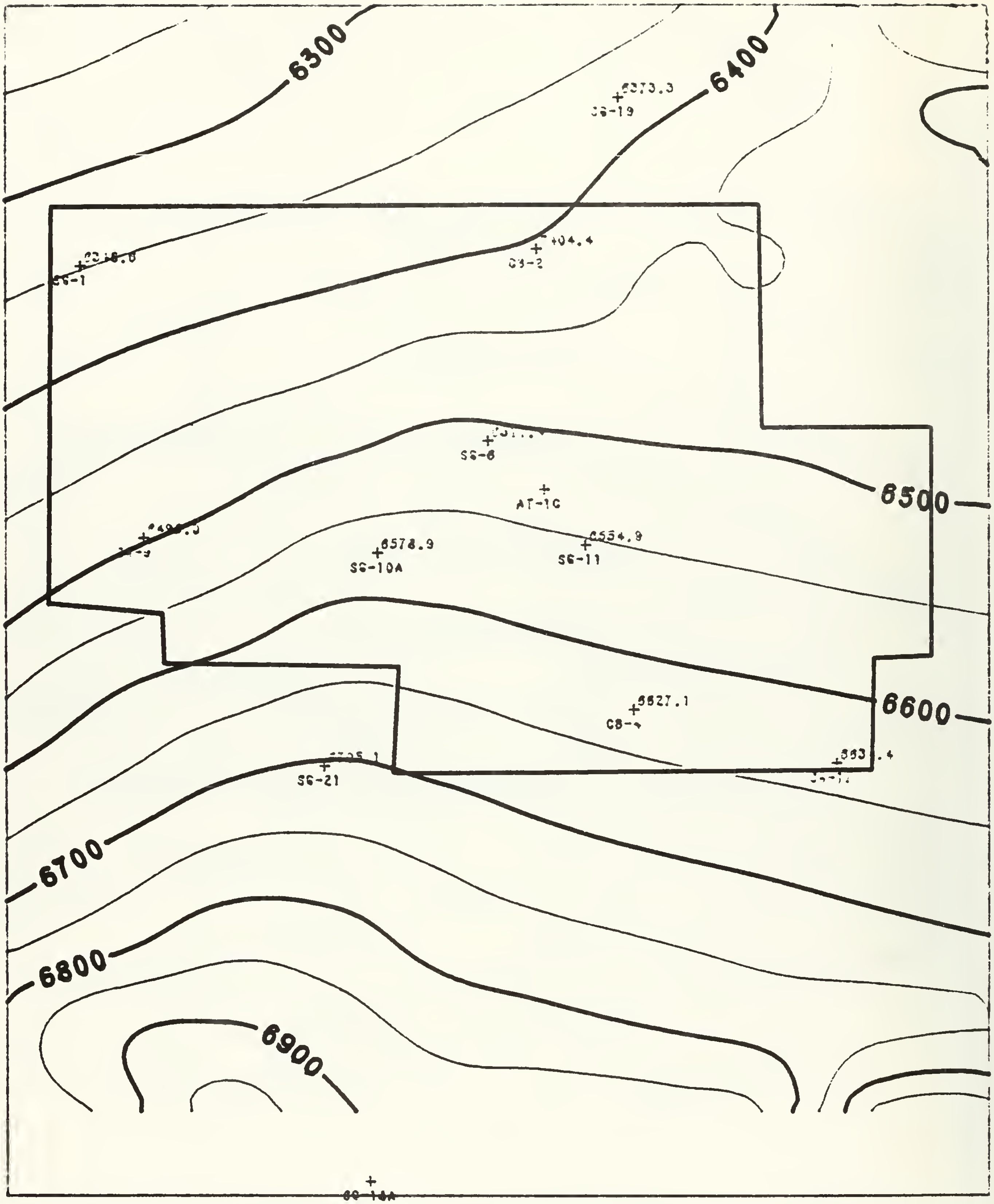


FIGURE A5.3.2B-16 Potentiometric Surface Map - Upper Aquifer, November 1978

Figure A6.2.1-1 CHANNEL "UPTIME" TIME-LINES

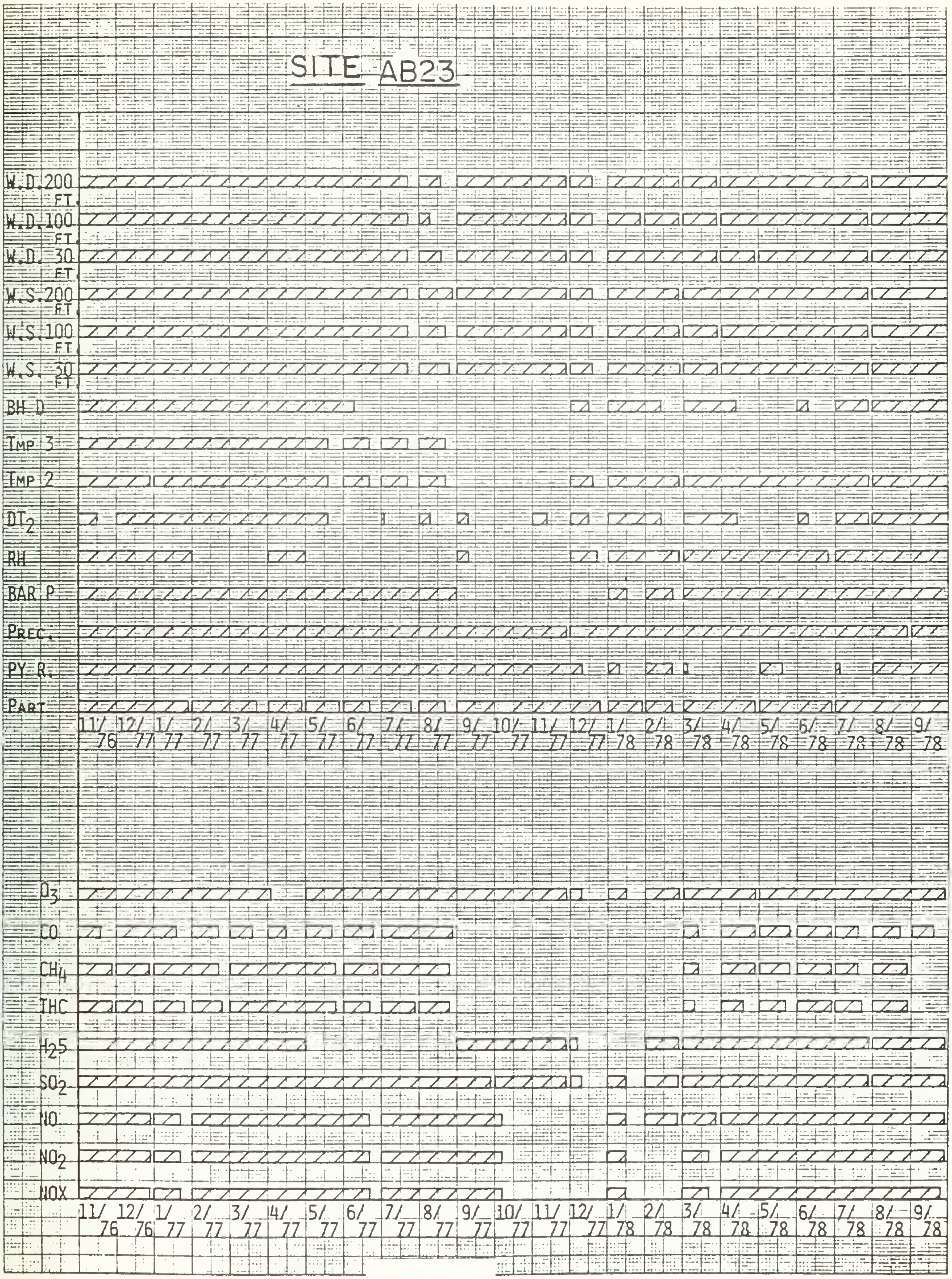


Figure A6.2.1-2 CHANNEL "UPTIME" TIME-LINES

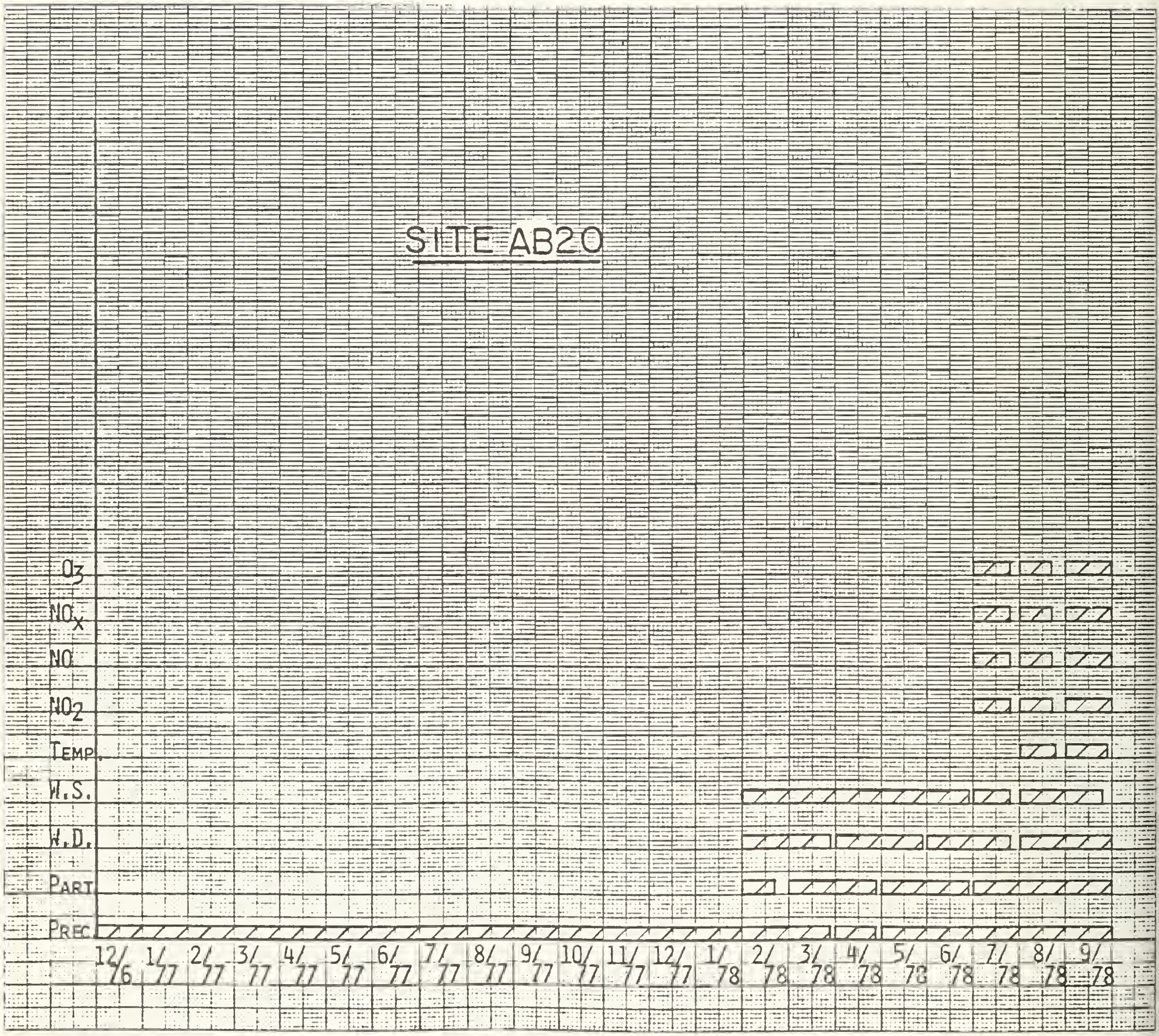
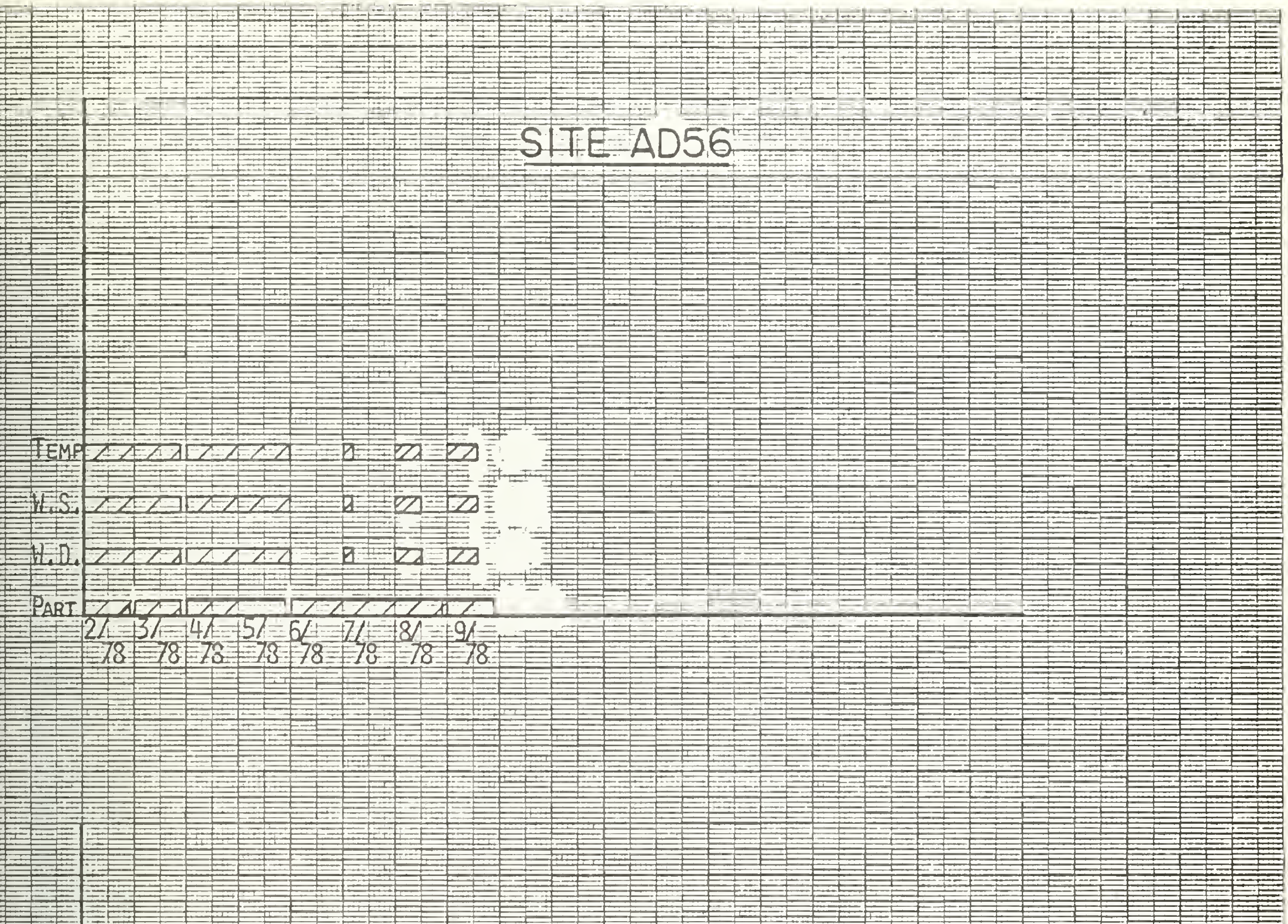


Figure A6.2.1-3 CHANNEL "UPTIME" TIME-LINES



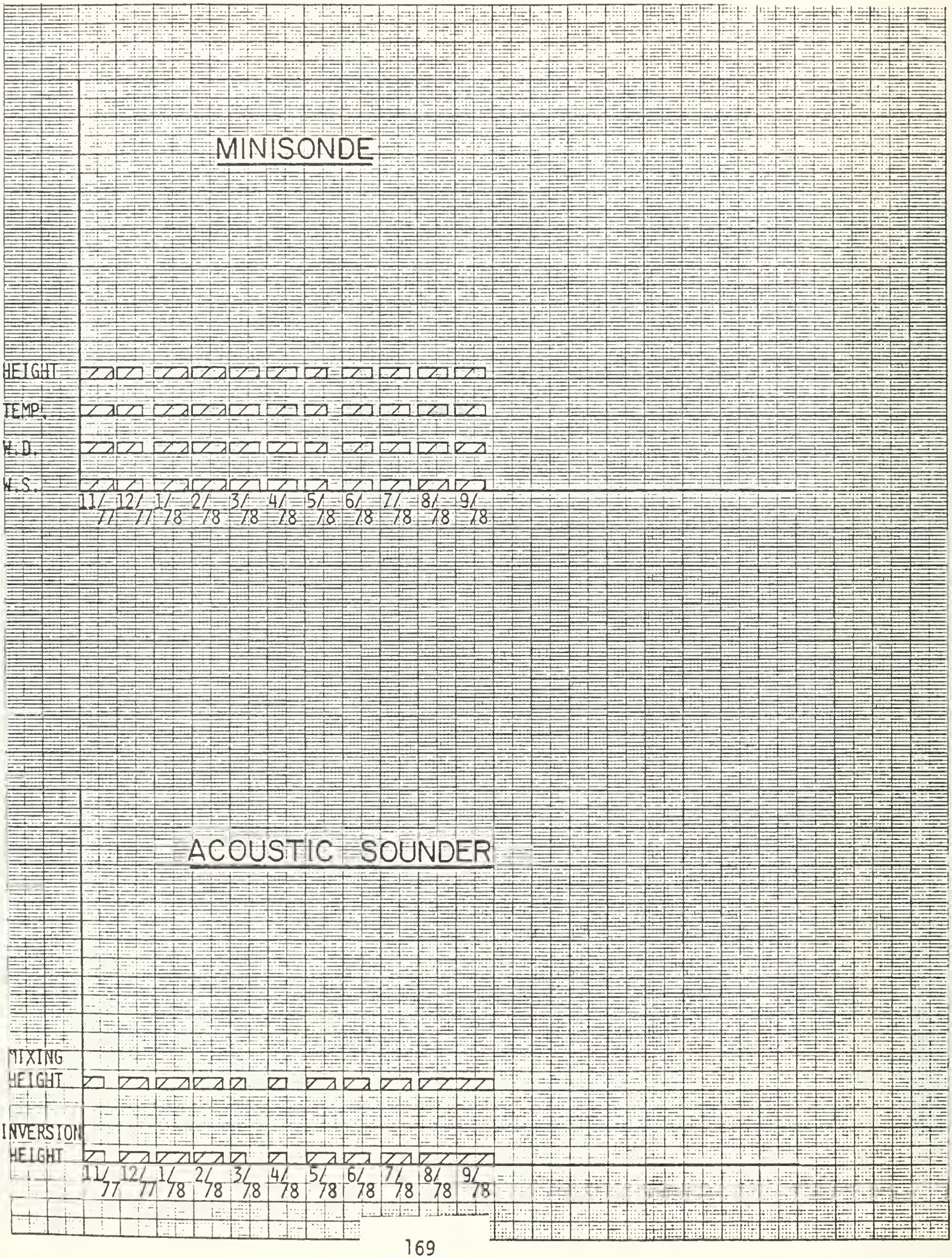


Figure A6.2.1-4 CHANNEL "UPTIME" TIME-LINES

TABLE A6.2.1-1

INSTRUMENT SPECIFICATIONS

These specifications apply to the analyzer types and time periods indicated. In some cases, current instruments will have different specifications, generally reflecting enhanced accuracy and sensitivity.

Sulfur dioxide/hydrogen sulfide November 1974 - March 1977 - Meloy SA-185-2

Range:	0 - 1 ppm (1000 ppb)
Lower Detection Limit:	.005 ppm
Noise:	± 0.5% (full scale)
Zero Drift:	± 1% per day
Span Drift:	± 1% per day
Precision:	± 1% (full scale)

March 1977 - September 1978 - Meloy SA-185-2A

Range:	0 - .5 ppm
Lower Detection Limit:	.002 ppm
Noise:	.005 ppm
Zero Drift:	.001 ppm (24 hours)
Span Drift:	3.2% (80% URL)
Precision:	.001 ppm S.D. (20% URL) .002 ppm S.D. (80% URL)

Carbon Monoxide November 1974 - August 1978 - Bendix 8200 Environmental Chromatograph

Range:	0 - 1 ppm to 0 - 100 ppm, stepped
Noise:	0.5% of full scale
Zero Drift:	< 1% per day
Span Drift:	< 1% per day
Precision:	± 1% of full scale

TABLE A6.2.1-1 (cont.)

September 1978 - Beckman Model 866 - Ambient CO Monitoring System

Range: 0 - 50 ppm

Lower Detection Limit: 0.4 ppm

Noise: 0.2 ppm S.D.

Zero Drift: ± 0.5 ppm (24 hours)

Span Drift: ± 1% full scale

Precision: ± 0.2 ppm S.D. full scale

Oxides of Nitrogen November 1974 - December 1977 - Meloy NA-520-2 Chemicuminizer

Range: 0 - .5 ppm

Lower Detection Limit: .005 ppm

Noise: .005 ppm

Zero Drift: .005 ppm (24 hours)

Span Drift: .010 ppm (24 hours)

Precision: ± 1% full scale

January 1978 - September 1978 - Monitor Labs Model 8440E Nitrogen Oxides Analyzer

Range: 0 - .5 ppm

Lower Detection Limit: .002 ppm

Noise: .001 ppm S.D.

Zero Drift: <. .003 ppm / 7 days

Span Drift: < 4% / 7 days

Precision: .004 ppm S.D. at 0.1 ppm

TABLE A6.2.1-1 (cont.)

Ozone November 1974 - September 1978 - Meloy OA-350-2 - Ozone Analyzer

Range:	0 - .5 ppm
Lower Detection Limit:	.0005 ppm
Noise:	± .3%
Zero Drift:	± 1% full scale/24 hours
Span Drift:	< ± full scale/24 hours
Precision:	± 2% full scale

TABLE A6.2.1-2

ERROR ANALYSIS DERIVATION

Random error distribution about a mean is best described by the standard deviation

$$\delta_x = \left(\frac{\Sigma_i \ (X_i-\overline{X})^2}{n-1}\right)^{\frac{1}{2}} \qquad \underline{\text{EQUATION 1}}$$

It should be noted that the term $(X_i-\overline{X})^2$ causes large errors to impact δ_x to a higher degree than smaller errors.

Hagen postulates:

1. Errors are unavoidable

2. observed errors are a composite of smaller errors of equal magnitude.
3. elementary error has an equal probability of having a positive as well as a negative effect. The number of elementary errors become infinite as the magnitude of error diminishes.

The postulate may be expressed as:

$$y = he^{-h^2X^2}\pi^{-\frac{1}{2}} \qquad \underline{\text{EQUATION 2}}$$

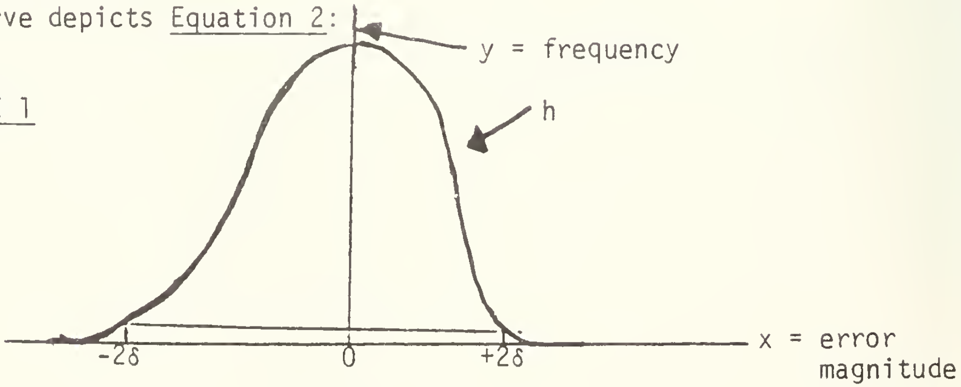
h = constant, x = precision modulus, x = error magnitude, y = frequency of error occurrence

h may be expressed as:

$$h = \{\delta(2^{\frac{1}{2}})\}^{-1} \qquad \underline{\text{EQUATION 3}}$$

The following curve depicts Equation 2:

FIGURE 1



The following features are evident from the curve in Figure 1:

1. Curve is symetrical about the y - axis
2. The largest errors occur at minimum frequency and fall off according to e^{-X^2}.
3. For large h values (very precise measurements) small errors occur at higher frequency than cases for small values of h.

The variable y may also be viewed in terms of probability law such that:

$$y = \frac{dP}{dX}$$ **EQUATION 4**

where, P is the probability of an analyzer's response to a known input. Therefore,

$$P = \int_{-\infty}^{+\infty} y dX = 1$$ **EQUATION 5**

From equation 2, h is a constant of integration and upon evaluation is determined to be $\frac{h}{\pi}$. By substitution Equation 4 becomes:

$$P = \frac{h}{\pi} \int_{-\infty}^{+\infty} e^{-h^2 X^2} \; dX$$ **EQUATION 6**

The limits of integration can be expressed as mean deviation:

$$a_X = \frac{\Sigma_i \left| X_i - \overline{X} \right|}{n}$$ **EQUATION 7**

or the standard deviation (Equation 1).

From Equation 1, X = error magniture, then δ_X would represent the magnitude of error for a data set.

From Equation 3, Equation 6 may now be expressed as:

$$P = \{\delta(2\pi)^{\frac{1}{2}}\}^{-1} \int_{-\delta}^{+\delta} e^{-X^2 \; 2\delta^2} \; dX$$ **EQUATION 8**

The area under the curve defined by the limits of this integration represents a 68% confidence level. 2δ would provide a 95% confidence level.

Error Propagation:

Error propagation results from instrument component contribution and operational error. Accepting the validity of the Hagens postulates for random error the following equation is presented:

$$dR = \frac{\partial R}{\partial X}\bigg|_{y,Z} dX + \frac{\partial R}{\partial Y}\bigg|_{X,Z} dy + \frac{\partial R}{\partial Z}\bigg|_{X,y} dZ \qquad \underline{\text{EQUATION 9}}$$

where R = component for which error evaluation is desired and x,y,z, are analyzer components contributing to error in R such that R = f(X,y,Z).

Since dX, dy, and dZ represent deviation from some X, y, Z then δX, δy and δZ could be substituted.

The general case for $\delta_X{}^2$ where n is large may be expressed as:

$$\delta_X{}^2 = \Sigma \frac{(dX)^2}{N} \qquad \underline{\text{EQUATION 10}}$$

To substitute the $\delta_X{}^2$ definition into Equation 9, it must first be squared:

$$(dR)^2 = \left(\frac{\partial R}{\partial X} dX + \frac{\partial R}{\partial y} dy + \frac{\partial R}{\partial Z} dZ\right)^2 \qquad \underline{\text{EQUATION 11}}$$

Upon the summation of the terms from the squaring and considering that dX and dy are independent of each other and recalling from Hagens postulates that there is equal probability of positive and negative values for dX and dy, the positive terms will cancel the negative ones and Equation 11 becomes:

$$\Sigma (dR_i)^2 = \left(\frac{\partial R}{\partial X}\right)^2 \Sigma (dX_i)^2 + \left(\frac{\partial R}{\partial y}\right)^2 \Sigma (dy_i)^2 + \left(\frac{\partial R}{\partial Z}\right) \Sigma (dZ_i)^2 \qquad \underline{\text{EQUATION 12}}$$

The form of Equation 10 may be obtained by dividing by N:

$$\frac{\Sigma_i (dR_i)^2}{N} = \left(\frac{\partial R^2}{\partial y}\right)^2 \frac{\Sigma_i \ (dX_i)^2}{N} + \ldots. \qquad \text{EQUATION 13}$$

substituting $\delta^2 = \Sigma \frac{(dX)^2}{N}$

Equation 13 becomes:

$$\delta_R^2 = \left(\frac{\partial R}{\partial X}\right)^2 \delta_x^2 + \left(\frac{\delta R}{\delta y}\right)^2 \delta_y^2 \quad \ldots. \qquad \text{EQUATION 14}$$

Equation 14 is the final form from which error propagation may be calculated.

Table A6.2.1-3a

DIURNAL VARIATION OF SO2 DIFFERENCE OF UNIT2 - UNIT1 (UG/M3)
STATION AB23
April 1977
HOUR

DY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	1	2	2	2	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
3	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
4	1	1	2	2	1	0	1	2	2	1	0	0	0	0	1	0	0	0	0	0	0	0	0	2
5	2	1	2	2	1	0	1	2	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	2	1	2	2	2	3	2	3	3	3	4	5	5	6
14	5	6	4	6	6	5	7	6	7	5	3	2	1	1	0	3	0	0	0	0	0	0	0	2
15	2	2	3	3	2	2	2	2	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	14	15	15	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	-1	-1	-1	-1	-2	-1	-2	-2	-1	-1	-2	-1	-1	-1	0
25	0	-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0

Mean .289
Standard Deviation = 1.34

Unit 1 = SA185-2A Analyzer
Unit 2 = SA185-2 Analyzer

Table A6.2,1-3b

DIURNAL VARIATION OF SO2 DIFFERFNCE OF UNIT2 - UNIT1 (UG/M3)
STATION AB23
May 1977
HOUR

DY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	0	-1	-2	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	2
3	3	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	1	1	0	0	0	1	3	2	3	2	3	2	4	4	4	5	5
5	5	5	5	6	4	4	6	6	6	2	0	0	0	0	0	0	0	0	0	1	0	2	2	2
6	2	2	2	2	1	0	0	1	2	1	0	0	0	0	2	0	0	0	0	1	2	2	4	3
7	3	4	4	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	-1	0
10	0	0	-1	-1	-1	-1	0	-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	6	3	1	3	3	2	0	0	0	0	0	3	9	10	6	2	1	2	3	5	7
17	8	9	8	0	0	0	0	0	0	-2	-2	-2	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	2	1	0	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	1	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	3	1	1	2	2	1	1	0	0	0	0	2	2	1	0	1	2	3	4	5	6
24	6	6	6	0	0	0	0	0	0	0	0	0	0	0	0	2	3	3	4	4	5	5	7	7
25	6	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2
29	2	2	2	2	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	3	2	1	2	3	2	0	0	0	0	0	0	0	0	0	0	0	0	2	2	3

Mean = .535
Standard deviation = 1.48

Unit 1 - SA185-2A Analyzer
Unit 2 - SA185-2 Analyzer

Table A6.2-1-3c

DIURNAL VARIATION OF SO2 DIFFERENCE OF UNIT2 - UNIT1 (UG/M3)
STATION AB23
June 1977
HOUR

DY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	3	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0
3	0	0	0	-2	-2	-2	-2	-2	-1	-1	-1	-1	-2	-1	-1	-1	0	-1	-2	-1	-2	-2	-2	-2
4	-2	-2	-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	7	6	4	5	5	5	5	4	5	5	4	5	6	6
8	6	7	6	0	0	0	0	0	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	1	2	1	2	2	2	1	0	1	2	2	3	3	2
10	2	4	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1
14	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	2	2	2	2	3	3	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	2	1	0	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
19	2	2	3	0	1	7	19	26	29	13	3	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	2	5	2	2	2	2	1	0	2	2	2	2	3	3	3	2	3	3	4	5	5
21	5	5	6	5	8	9	8	6	6	5	3	2	1	0	1	2	2	1	0	0	2	5	6	7
22	8	9	11	1	4	6	10	11	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	1	10	19	25	32	24	10	4	1	0	0	0	0	0	0	0	0	0	0	0
24	0	0	1	7	10	9	6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Mean = .96
Standard Deviation = 3.17

Unit 1 = SA185-2A Analyzer
Unit 2 = SA185-2 Analyzer

Table A6.2.1-3d

DIURNAL VARIATION OF SO2 DIFFERENCE OF UNIT2 - UNIT1 (UG/M3)
STATION AB23
July 1977
HOUR

DY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
2	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
3	0	0	1	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	1	0
4	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	1	0	1	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0
7	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	1	0	0
8	0	0	0	0	0	0	0	0	0	7	2	0	0	0	0	0	0	0	0	0	0	0	0	1
9	2	2	5	5	5	2	6	4	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
10	0	5	7	7	6	3	5	6	5	1	0	0	1	1	0	0	0	0	0	0	0	0	3	7
11	6	8	8	8	7	7	9	0	2	0	1	0	0	1	0	1	0	0	0	1	1	0	1	0
12	3	5	4	6	6	5	7	7	6	0	0	1	1	0	1	1	1	2	2	2	1	2	1	1
13	1	0	1	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	1	1	2	0	0	1	1	1	2	1	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	2	2	2	2	1	0	0
29	0	1	0	1	1	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Mean = 0.47
Standard Deviation = 1.49

Unit 1 - SA185-2A Analyzer
Unit 2 - SA185-2 Analyzer

FIGURE A6.2.1-5

QUARTERLY SO_2 CONCENTRATION ROSES, STATION AB23 (1976-1978)

QUARTERLY SO2 CONCENTRATION ROSE
DEC '76 - FEB '77

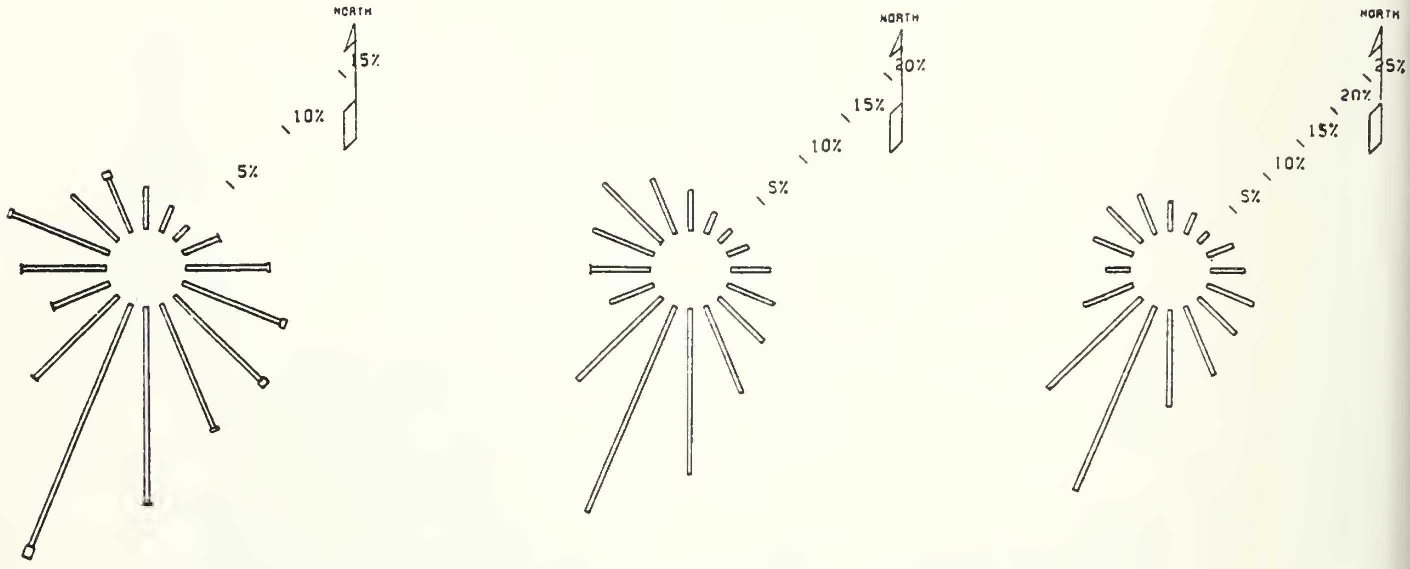
TOTAL % OF CALMS DISTRIBUTED (0000%)
TOTAL NO. OF 1 HOUR SAMPLES -2078

QUARTERLY SO2 CONCENTRATION ROSE
MAR '77 - MAY '77

TOTAL % OF CALMS DISTRIBUTED (0000%)
TOTAL NO. OF 1 HOUR SAMPLES -2129

QUARTERLY SO2 CONCENTRATION ROSE
JUN '77 - AUG '77

TOTAL % OF CALMS DISTRIBUTED (0.00%)
TOTAL NO. OF 1 HOUR SAMPLES -1538



QUARTERLY SO2 CONCENTRATION ROSE
SEP '77 - NOV '77

TOTAL % OF CALMS DISTRIBUTED (0000%)
TOTAL NO. OF 1 HOUR SAMPLES -1381

QUARTERLY SO2 CONCENTRATION ROSE
DEC '77 - FEB '78

TOTAL % OF CALMS DISTRIBUTED (0000%)
TOTAL NO. OF 1 HOUR SAMPLES -1147

QUARTERLY SO2 CONCENTRATION ROSE
MAR '78 - APR '78

TOTAL % OF CALMS DISTRIBUTED (0000%)
TOTAL NO. OF 1 HOUR SAMPLES -1272

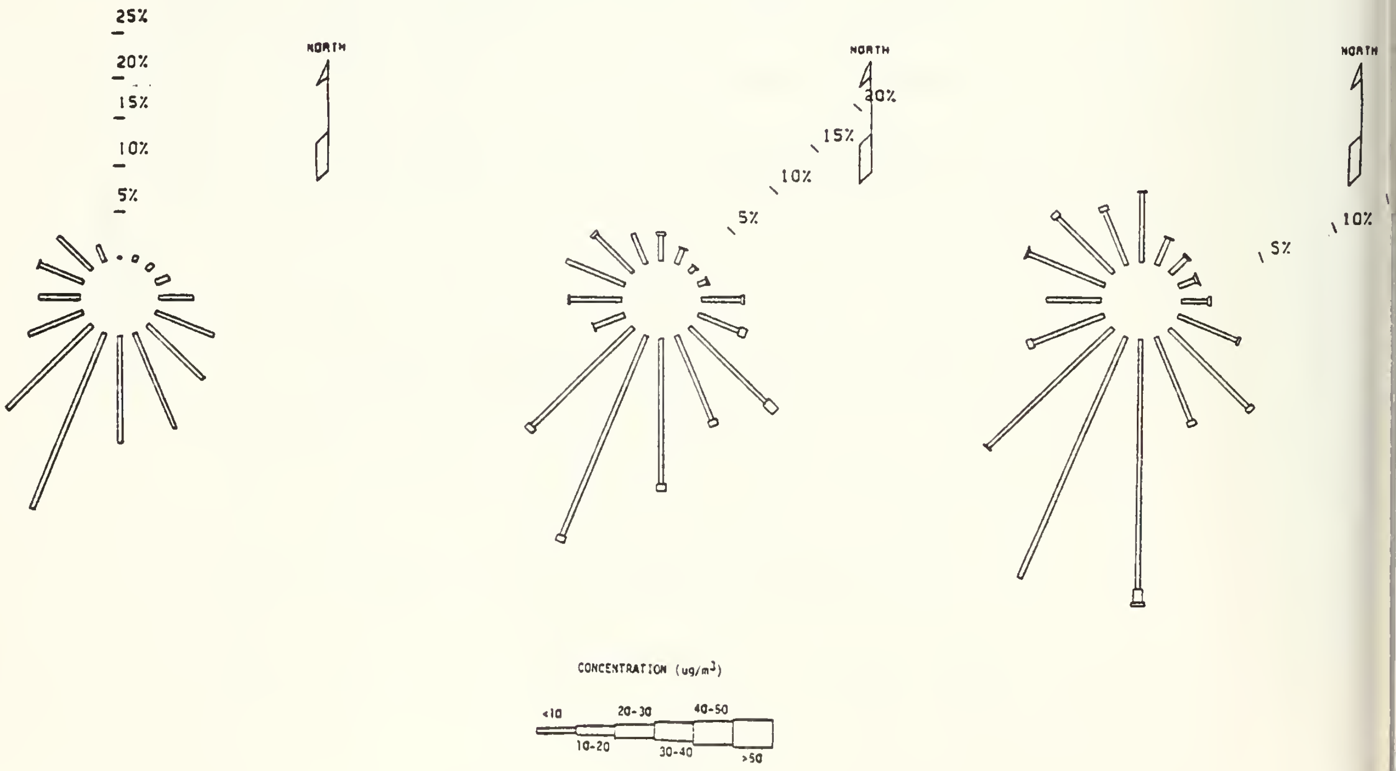
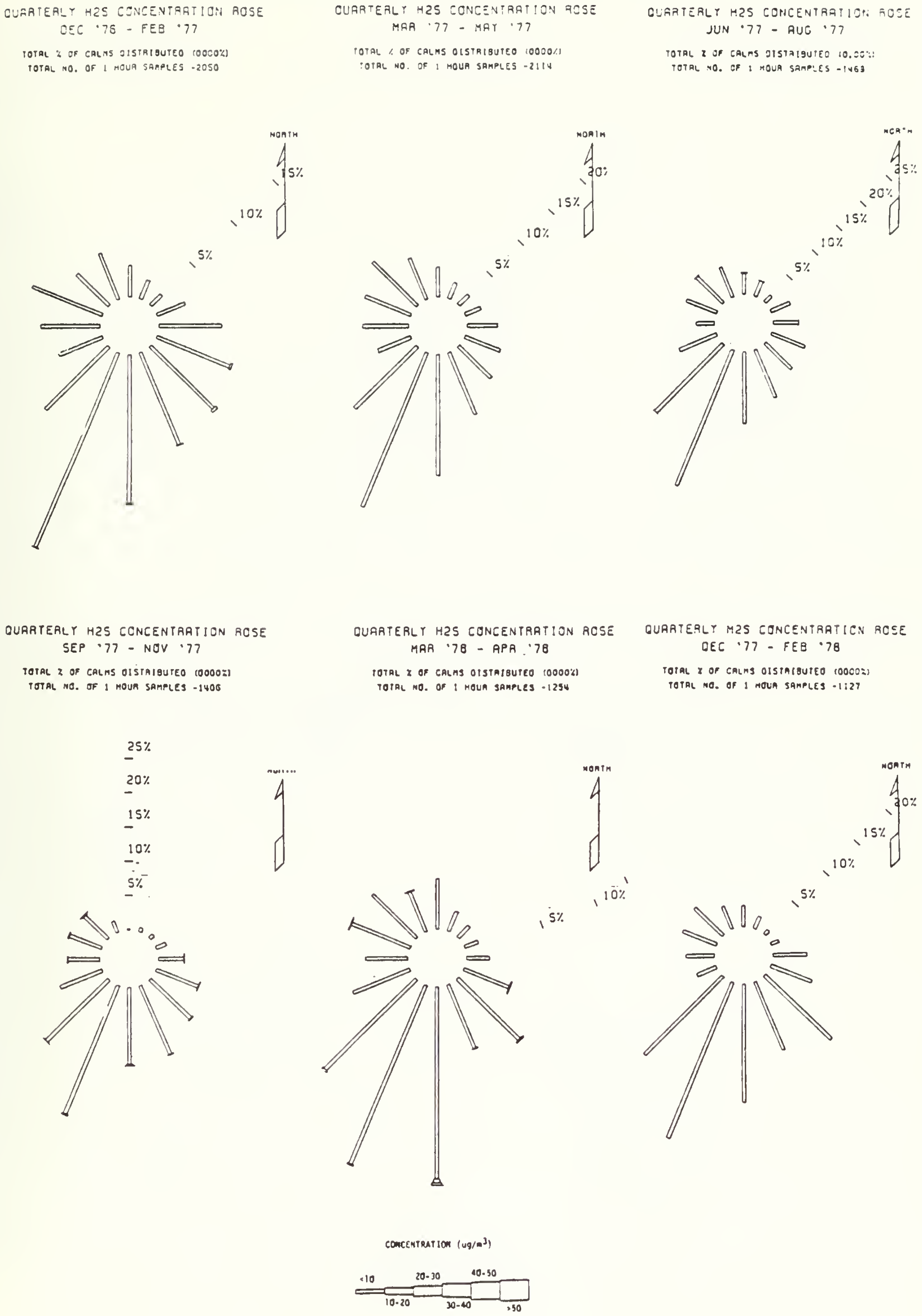


FIGURE A6.2.1-6

QUARTERLY H_2S CONCENTRATION ROSES, STATION AB23 (1976-1978)



QUARTERLY H2S CONCENTRATION ROSE
DEC '76 - FEB '77
TOTAL % OF CALMS DISTRIBUTED (0000%)
TOTAL NO. OF 1 HOUR SAMPLES -2050

QUARTERLY H2S CONCENTRATION ROSE
MAR '77 - MAY '77
TOTAL % OF CALMS DISTRIBUTED (0000%)
TOTAL NO. OF 1 HOUR SAMPLES -2114

QUARTERLY H2S CONCENTRATION ROSE
JUN '77 - AUG '77
TOTAL % OF CALMS DISTRIBUTED (0.00%)
TOTAL NO. OF 1 HOUR SAMPLES -1463

QUARTERLY H2S CONCENTRATION ROSE
SEP '77 - NOV '77
TOTAL % OF CALMS DISTRIBUTED (0000%)
TOTAL NO. OF 1 HOUR SAMPLES -1406

QUARTERLY H2S CONCENTRATION ROSE
MAR '78 - APR '78
TOTAL % OF CALMS DISTRIBUTED (0000%)
TOTAL NO. OF 1 HOUR SAMPLES -1254

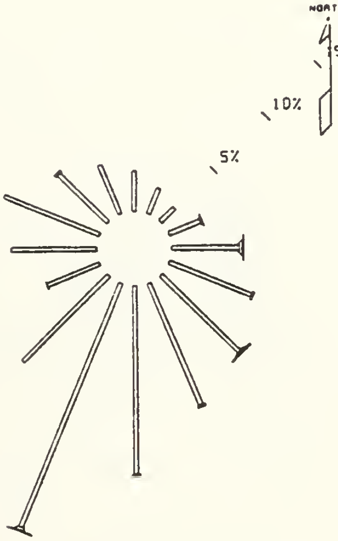
QUARTERLY H2S CONCENTRATION ROSE
DEC '77 - FEB '78
TOTAL % OF CALMS DISTRIBUTED (0000%)
TOTAL NO. OF 1 HOUR SAMPLES -1127

FIGURE A6.2.1-7

QUARTERLY NOX CONCENTRATION ROSES, STATION AB23 (1976-1978)

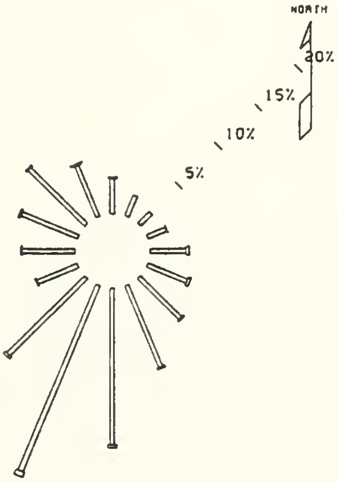
QUARTERLY NOX CONCENTRATION ROSE
DEC '76 - FEB '77

TOTAL % OF CALMS DISTRIBUTED (0000%)
TOTAL NO. OF 1 HOUR SAMPLES -1773



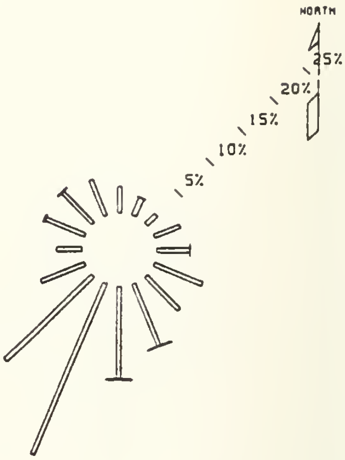
QUARTERLY NOX CONCENTRATION ROSE
MAR '77 - MAY '77

TOTAL % OF CALMS DISTRIBUTED (000O%)
TOTAL NO. OF 1 HOUR SAMPLES -2048



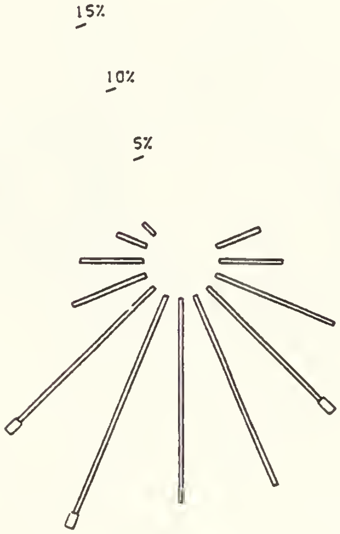
QUARTERLY NOX CONCENTRATION ROSE
JUN '77 - AUG '77

TOTAL % OF CALMS DISTRIBUTED (0.00%)
TOTAL NO. OF 1 HOUR SAMPLES -1182



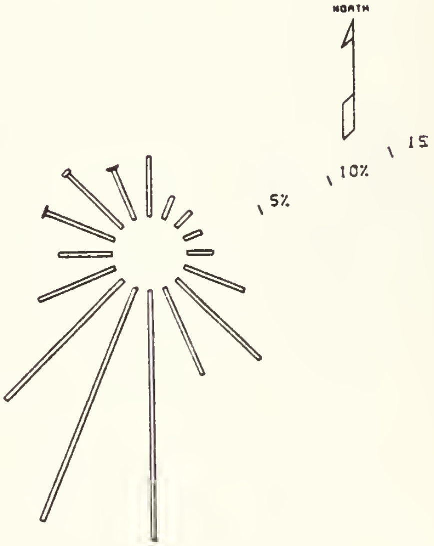
QUARTERLY NOX CONCENTRATION ROSE
SEP '77 - OCT '77

TOTAL % OF CALMS DISTRIBUTED (0000%)
TOTAL NO. OF 1 HOUR SAMPLES -63



QUARTERLY NOX CONCENTRATION ROSE
MAR '78 - APR '78

TOTAL % OF CALMS DISTRIBUTED (0000%)
TOTAL NO. OF 1 HOUR SAMPLES -114E



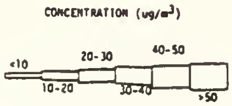


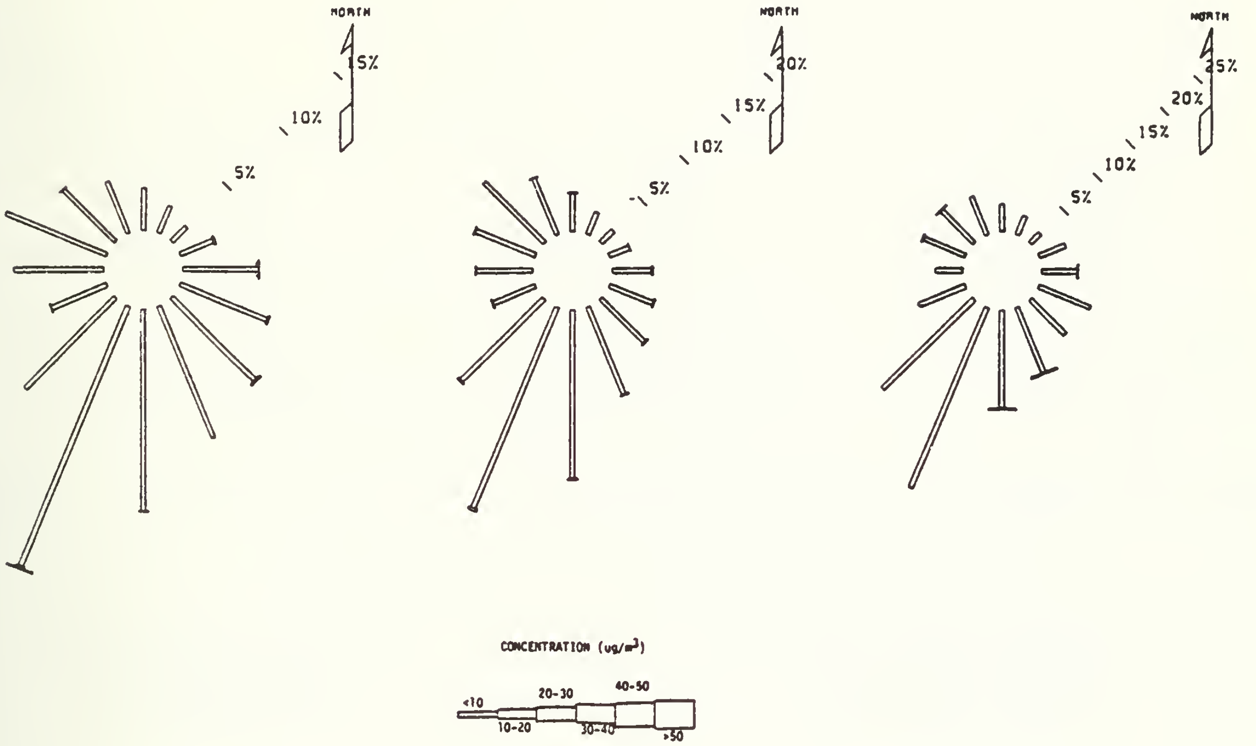
FIGURE A6.2.1-8

QUARTERLY NO_2 CONCENTRATION ROSES, STATION AB23 (1976-1978)

QUARTERLY NO2 CONCENTRATION ROSE
DEC '76 - FEB '77
TOTAL % OF CALMS DISTRIBUTED (0000%)
TOTAL NO. OF 1 HOUR SAMPLES -1773

QUARTERLY NO2 CONCENTRATION ROSE
MAR '77 - MAY '77
TOTAL % OF CALMS DISTRIBUTED (0000%)
TOTAL NO. OF 1 HOUR SAMPLES -2048

QUARTERLY NO2 CONCENTRATION ROSE
JUN '77 - AUG '77
TOTAL % OF CALMS DISTRIBUTED (0.00%)
TOTAL NO. OF 1 HOUR SAMPLES -1182



QUARTERLY NO2 CONCENTRATION ROSE
SEP '77 - OCT '77
TOTAL % OF CALMS DISTRIBUTED (0000%)
TOTAL NO. OF 1 HOUR SAMPLES -93

QUARTERLY NO2 CONCENTRATION ROSE
MAR '78 - APR '78
TOTAL % OF CALMS DISTRIBUTED (0000%)
TOTAL NO. OF 1 HOUR SAMPLES -1143

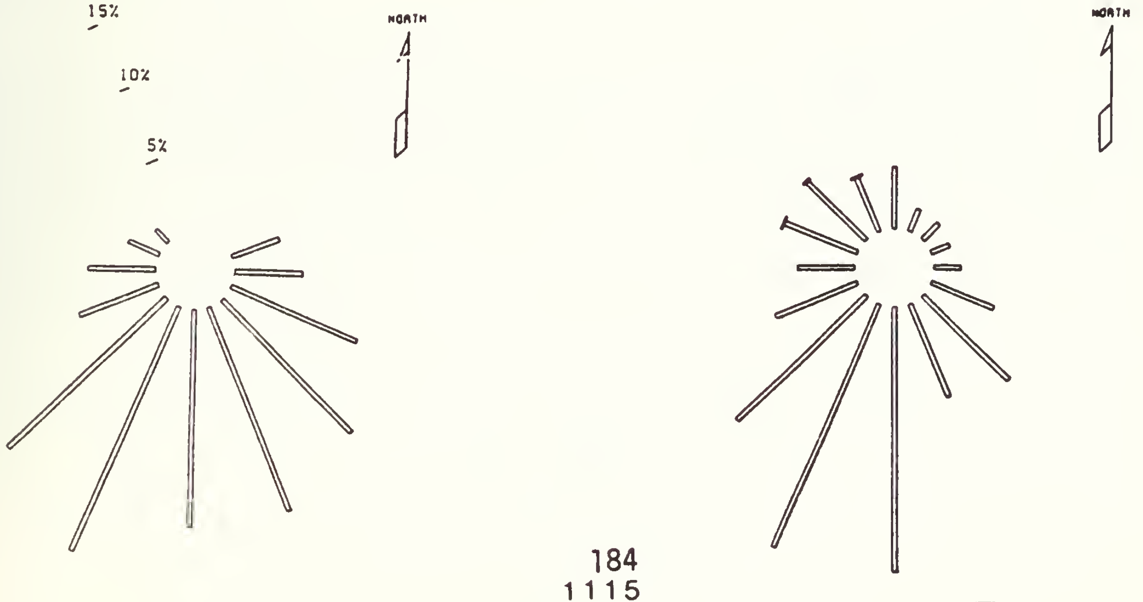


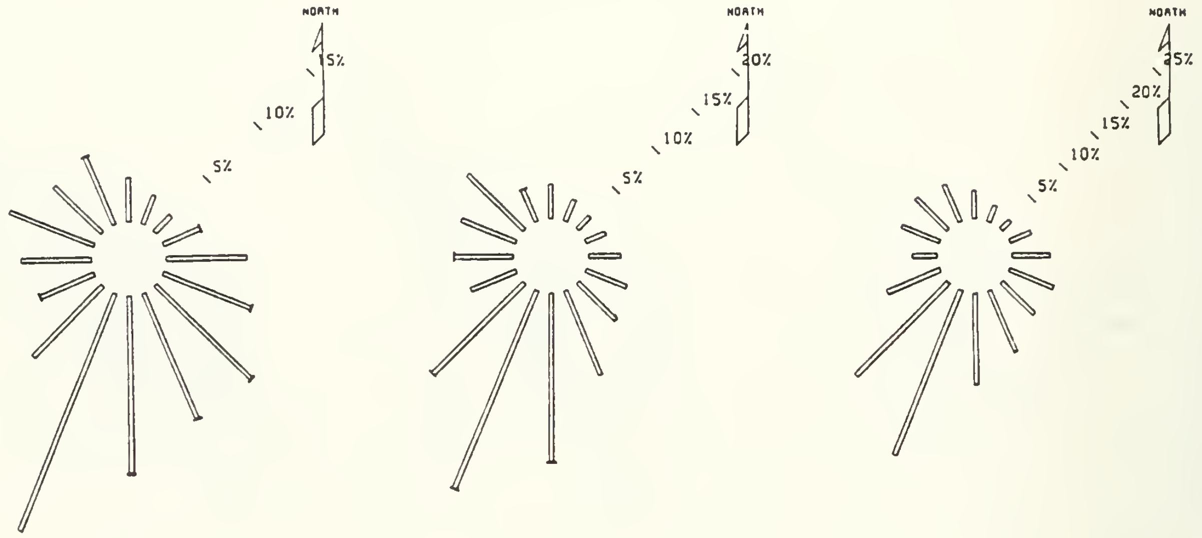
FIGURE A6.2.1-9

QUARTERLY CO CONCENTRATION ROSES, STATION AB23 (1976-1978)

QUARTERLY CO CONCENTRATION ROSE
DEC '76 - FEB '77
TOTAL % OF CALMS DISTRIBUTED (0000%)
TOTAL NO. OF 1 HOUR SAMPLES -1513

QUARTERLY CO CONCENTRATION ROSE
MAR '77 - MAY '77
TOTAL % OF CALMS DISTRIBUTED (0000%)
TOTAL NO. OF 1 HOUR SAMPLES -1161

QUARTERLY CO CONCENTRATION ROSE
JUN '77 - AUG '77
TOTAL % OF CALMS DISTRIBUTED (0.00%)
TOTAL NO. OF 1 HOUR SAMPLES -1246



QUARTERLY CO CONCENTRATION ROSE
SEP '77 - NOV '77
TOTAL % OF CALMS DISTRIBUTED (0000%)
TOTAL NO. OF 1 HOUR SAMPLES -288

QUARTERLY CO CONCENTRATION ROSE
MAR '78 - APR '78
TOTAL % OF CALMS DISTRIBUTED (0000%)
TOTAL NO. OF 1 HOUR SAMPLES -817

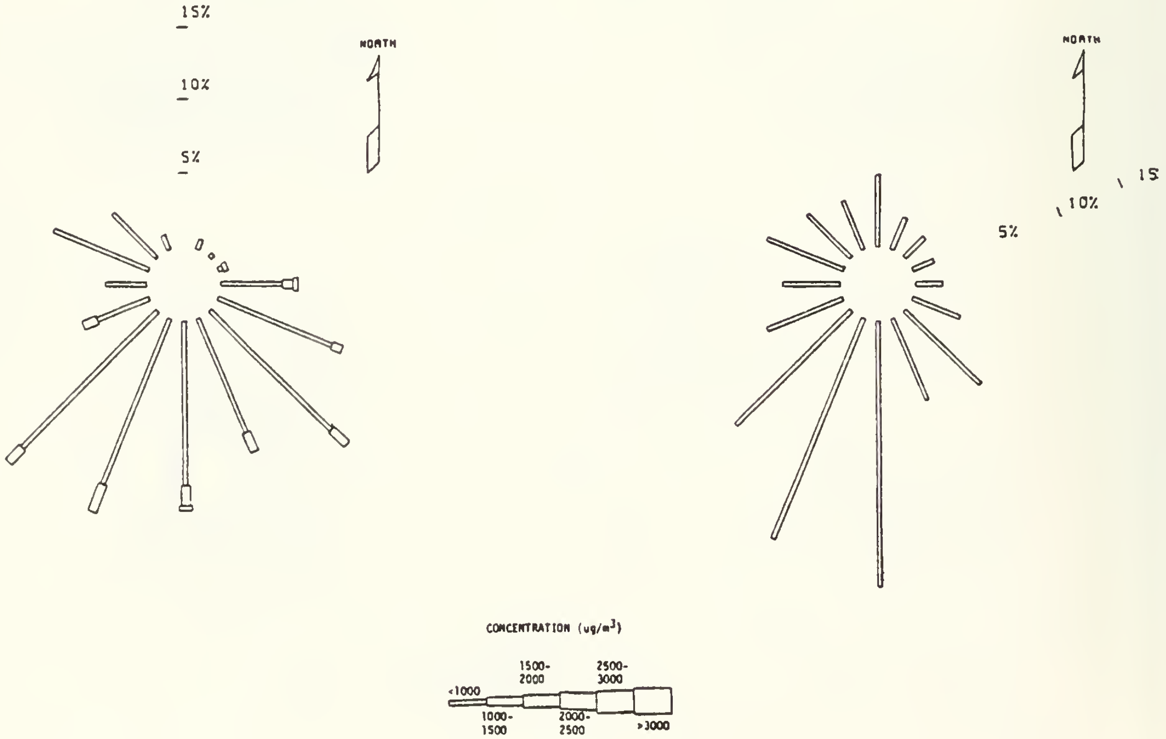


Table A6.2.1-4

UNIVARIATE TIME SERIES ANALYSIS FOR OZONE AUGUST 1975

Station AB20

Parameter:	Ozone (8/75)(hours 433-744)	312 data points
Series:	Original	Differenced by 1 and 24
Series Mean:	42.6	0.101
Series Variance:	278.9	34.84
Trend at 95% Confidence Level:	0.0	0.0
Series Minimum:	8.0	-23.0
Series Maximum:	78.0	30.0
Chi-Sq. for Data:	2776. with 47 d.f.	99.4 with 47 d.f.
Chi-Sq. at 95% Level:	64.001 with 47 d.f.	64.001 with 47 d.f.

Model: (0,24,24)	$(1-B)^1(1-B)^2 z_t=0.090239+(1-.21382B^2)(1-.74195B^{24})a_t$	
Coef. of Det:	0.917 for original series	0.311
Residual Mean:		.179
Residual Variance:		23.77
Residual Minimum:		-17.0
Residual Maximum:		28.0
Residual Chi-Sq.:		28.09 with 21 d.f.
Chi-Sq. at 95% Level:		32.671 with 21 d.f.

Discussion: This is an ARIMA model based on a twice differenced series by lags of 1 and 24. The form of the model is (0,24,24). The autocorrelation function of the differenced series contained significant spikes at lags 2, 24, and 25. The trend term (.090239) was retained in the model even though it was not significant. The model has probably been overspecified in this case since the first difference of order 24 provided an autocorrelation function of lumpy, decaying exponential form similar to the hourly ozone series modeled for station AB23 August 1977 series.

Based on autocorrelation function comparison, this series is judged equivalent to AB23 August 1977 series except that the mean value is much lower.

NOTE: See Appendix A5.2.1D for discussion of Univariate Time Series Analysis.

Table A6.2.1-5

UNIVARIATE TIME SERIES ANALYSIS FOR OZONE AUGUST 1977

Station AB23

Parameter:	Ozone 8/77 (116-403)	
Series:	Original (288 hours)	Differenced by 24
Series Mean:	96.1	0.443
Series Variance:	333.75	287.37
Trend at 95% Confidence Level:	0.0	0.0
Series Minimum:	31.0	
Series Maximum:	129.0	
Chi-Sq. for Data:	1480.3 with 47 d.f.	690.00 with 46 d.f.
Chi-Sq. at 95% Level:	64.001 with 47 d.f.	62.830 with 46 d.f.
Model: (1,24,24)	$(1-.86896B^{1})(z_t)=(1-.70217B^{24})a_t$	
Coef. of Det.		
Residual Mean:		0.24221
Residual Variance:		66.313
Residual Minimum:		
Residual Maximum:		
Residual Chi-Sq.:		47.884
Chi-Sq. at 95% Level:		62.830 with 46 d.f.

Discussion: This is an ARIMA model of the form (1,24,24). The model was based on differencing once by 24 lags to obtain an autocorrelation function of a lumpy, decaying exponential form. Significant lags occurred in the PACF of the differenced series at lags 1 and 24. Lag 1 was retained in the autoregressive term and lag 24 retained in the moving average term. Trend was insignificant for both original and differenced series. Forecast model fits data well and accounts for diurnal cycle of 24 hours.

NOTE: See Appendix A5.2.1D for discussion of Univariate Time Series Analysis.

Table A6.2.1-6

UNIVARIATE TIME SERIES ANALYSIS FOR OZONE AUGUST 1975

Station AB23

Parameter:	Ozone 8175 (hours 433-744)	312 data points
Series:	Original	Differenced by 1 and 24
Series Mean:	52.3	.167
Series Variance:	204.57	36.34
Trend at 95% Confidence Level:		0.0
Series Minimum:	18.	
Series Maximum:	126.	
Chi-Sq. for Data:	1298 with 47 d.f.	
Chi-Sq. at 95% Level:	64.001 with 47 d.f.	
Model: (0,24,24)	$(1-B)^1(1-B)^2 z_t=.11026+(1+.24528B-.10950B^6-.65533B^{24})a_t$	
Coef. of Det:	.784	.275
Residual Mean:		.0772
Residual Variance:		25.97
Residual Minimum:		-43.
Residual Maximum:		+36.
Residual Chi-Sq.:		27.87 with 28 d.f.
Chi-Sq. at 95% Level:		41.337 with 28 d.f.

Discussion: This is an ARIMA model based on twice differenced series by lags of 1 and 24. The form of the model is (0,24,24) with the moving term containing three parameters of order 1, 6, and 24. The autocorrelation function of the differenced series contained random spikes that were significant at lags 1, 6, and 24. The trend parameter of .11026 was not significant but was retained in the final model. The model has probably been overspecified and could have been based on differencing by 24 only. The model and series is equivalent to that of ozone series for AB20, August 1975.

A model based on differencing once by 24 lags would likely yield a form similar to that of ozone series for AB23, August 1977 except for a much lower mean value.

NOTE: See Appendix A5.2.1D for discussion of Univariate Time Series Analysis.

Table A6.2.1-7

UNIVARIATE TIME SERIES ANALYSIS FOR PARTICULATES

Station AB23

Parameter:	Particulates (41 monthly data points)
Series Mean:	8.83171
Series Variance:	25.3322
Trend:	0.0 at 95% confidence level
Series Minimum:	1.10
Series Maximum:	19.30
Chi-Sq. for Data:	70.7666 with 39 d.f.
Chi-Sq. at 95% Level:	54.572 with 39 d.f.

Model: (12,0,0)	$(1-.60112B^{1})(1-.24026B^{12})(z_t-8.83171)=a_t$
Coef. of Det:	.402223
Residual Mean:	-.496612 = 0 at 95% confidence level
Residual Variance:	9.41857
Residual Minimum:	-4.71776
Residual Maximum:	10.9535
Residual Chi-Sq.:	13.4723 with 25 d.f.
Chi-Sq. at 95% Level:	37.652 with 25 d.f.

Discussion: This is an ARIMA (p,d,q) model where p = 12, d = 0, and q = 0. The partial-autocorrelation function of the data showed significant lags at times one and twelve. The trend term was insignificant at the 95% confidence level. Although the chi-square statistic for the data was significant, the residual chi-square was not significant, indicating that the model has successfully reduced the residuals to uncorrelated white noise. No actual forecasting was done using this model.

NOTE: See Appendix A5.2.1D for discussion of Univariate Time Series Analysis.

Table A6.2.1-8

UNIVARIATE TIME SERIES ANALYSIS FOR CARBON MONOXIDE

Station AB23

Parameter:	Carbon Monoxide (31 monthly data points filled in via forecasting.)
Series Mean:	816.040
Series Variance:	278064.
Trend:	0 at 95% confidence level
Series Minimum:	239.3
Series Maximum:	1847.30
Chi-Sq. for Data:	68.3723 with 15 d.f.
Chi-Sq. at 95% Level:	24.996 with 15 d.f.
Model: (1,0,0)	$(1-.81378B)(z_t-816.040)=a_t$
Coef. of Det:	0.637104
Residual Mean:	0 at 95% confidence level
Residual Variance:	98534.9
Residual Minimum:	-675.863
Residual Maximum:	661.020
Residual Chi-Sq.:	7.29373 with 14 d.f.
Chi-Sq. at 95% Level:	23.685 with 14 d.f.

Discussion: The above model is an ARIMA (p,d,q) model where p, the order of the AR term = 1, and d and q, the order of the differencing and MA terms, respectively = 0.

This data is considered too limited for a meaningful time series. However, modeling of the "filled in" data showed a residual mean of 0 and an insignificant trend term at 95% confidence level. The residual chi-square was not significant showing that the residuals had been reduced to noise.

NOTE: See Appendix A5.2.1D for discussion of Univariate Time Series Analysis.

APPENDIX A6.2.3

Site Log Sheets for 1978 Visibility Study

SITE LOG SHEETS

4/06/78

MST
0750 - Arrived site. Windy not to cold. Some sunshine but cloudy overhead. All views good visibility. Clouds on H on View 4. Road dry.

0830 - All views good - cl on hz on View 4 only. Real overcast on View 4. No haze anywhere. Still windy from southeast. Kinda unusual? Sun behind large cloud.

0930 - No haze. Clouds on H on View 4 only. Still windy, a little more sunshine.

1030 - Some haze, View 1 & 2. Shadows on View 1 & 2. Still windy, some sunshine with high wispy clouds.

1130 - High cloudiness, sun shining. Light hz on View 1 & 2. Cl on H on View 1, 2, 3.

1300 - High cloudiness, sun shining. Lt hz. View 1. Cl on H on View 1, 2, 3. Warm 50+ and windy.

1400 - High clouds. with sun, real light hz. View 1 & 2. Real clear on View 3 & 4. Shadows on View 1 & 2.

1500 - High clouds, general overcast, not too much sun. Light hz View 1 & 2 clear on View 3 & 4. Has been windy, blustry type spring day.

4/12/78

MST

0800 - Arrived site. Fantastic morning. Not a cloud in sky. Sunny.

0830 - No change. Light hz all views snow on View 3 & 4. Not too cold. No breeze. Hz a little more to the west.

0930 - Nice - slight breeze - SW. View 1 & 2. Have lt hz while View 3 & 4. Not too cold no breeze hz a little more to the west.

1030 - Same as 0930. Breeze picking up a little.

1130 - Lt Hz View 1. View 2, 3, 4 clear few scattered clouds. No cl on H some breeze from SW - Nice out.

1200 - Getting windy. Some scattered clouds. Very little hz on View 1 & 2. 3 & 4 clear. Still sunny most times clouds coming from east.

1400 - Windy with some pretty good gusts. Lt hz on View 1. View 2, 3, & 4 clear. More clouds.

1500 - Still windy - Snow on View 3. Almost gone. Some hz View 1. All other views clear. Not too warm now, otherwise real nice day.

Depart site

4/18/78

MST

0800 - Arrived site. Calm, mostly clear. All views visible.

0830 - Sunny with some cl. Lt hz all views. Cl on Hz on Views 2,3, 4. No cl on View 1, a patch of shadow between site & View 1. Not too cold. Snow on View 4.

0930 - Cl on H on View 3 & 4. Calm and real nice. Snow is gone on all views except View 4. Seem hazy in all directions today - windy yesterday.

1030 - Has turned windy, hz is almost gone except View 1. Cl on H on View 3 & 4. A few scattered cl now to the N.

1130 - Still windy, shadow on View 2. Ht hz. View 1 - Rest are clear scattered cl and sunny.

1300 - Continues to be windy - Lt hz View 1 & 2. Clear to the east.

1400 - No change - very few clouds left in sky now.

1500 - Same - Windy but otherwise has been a real nice day.

Depart site

4/24/78

MST
0800 - Calm, sunny day. All views visible. Some hz all views

0830 - No change. A few high wispy cl. Snow on View 4. No cl on H. Some dust or smoke in area of C-b worksite.

0930 - Cl on H View 1, 2, 3 - lt hz 1, 2, 3. No much Hz on View 4. Always heavier to the west. Small amount of dust can be seen from C-b work site. Sunny & lt. wind.

1030 - Cl on H View 1 & 2 lt hz west, View 3 & 4 not bad. Lt. wind has started.

1130 - Cl on horizon all views. Lt hz View 1 and 2. 3 & 4 mostly clear wind is picking up a little more. Sunny.

1300 - Quite a bit of wind, gusty. Cl on H all view lt hz. View 1 & 2 View 3 & 4 mostly clear becoming overcast.

1400 - Gusty winds at time. Cl on H all views. Shadow on View 3. Lt hz to the west, better to the east. Not as overcast as 1300.

1500 - Cl on H all views, Wind isn't quite as gusty, cloudy to the south Sunny - lt hz View 1 & 2, 3 & 4 pretty good.

Real nice day

SITE LOG SHEETS

4/30/78

MST

0805 - View 1 & 2 covered with clouds View 3 & 4 can be seen but not too clear. Overcast with some sun, light wind blowing from SW. Rain last night some shower to west and northwest.

0830 - Same as 0805. Some clearing on skyline to west.

0930 - No sun. Light rain total overcast. Can see View 4 only clouds on View 1, 2, & 3. Pictures taken from inside cabin.

1030 - All views in clouds, however close objects all view are visible. Sunny to south. Windy. Not raining at site now.

1130 - View 2 & 4 visible. Rain showers. Some sun to south. View 3 heavy clouds. View 1 clouds.

1300 - Good rain at site - overcast can see View 1. View 2, 3, & 4 covered with clouds. Wind, light out of SW. No sun now.

1400 - View 1 - Visible - some light cls on View 2. View 3 & 4 are covered with clouds. Rain showers to View 4 sun shining again. But mostly overcast.

1500 - View 1 & 2 visible. View 3 & 4 in clouds. Some sun, but mostly cloudy. About same all day.

Depart site

5/6/78

MST
0800 - 1" snow at site - overcast - with some sunshine. View 2 & 4 visibile with cl on View 1 & 4. Calm. Some blue skys too mostly overhead.

0830 - Cl on H all views. View 1, 2, 3 visible. View 4 in clouds. Calm. Overcast right now. Radio says 100% for showers & or snow today.

0930 - View 1 & 2 visible. View 3 just barely visible. View 4 snowing. Wind calm, a bit more cloudy - seems to be closing in a bit.

1030 - Weather getting worse. Can only see View 2. Storm moving west to east. Real light wind. No sun. Light snow on all higher areas.

1130 - View 1, 2, 3 visible. Snowing View 4. No sun. No wind. No warmth. Light snow & rain showers at sight. Not much change.

1300 - View 1 & 2 visible. Snowing elsewhere. Just minutes after pictures were taken a snowstorm at site.

1400 - All views snowing. Some sun overhead good snowstorm from NW.

1400 - Snowing all views. Sun overhead some wind. Not too hot a day.

Depart site

NOTE: Forgot to change the month on calibration card!

5/12/78

MST

0805 - Sunny with a few scattered clouds on horizon to North & NE. Breeze from SW. Nice morning.

0830 - Cl on H on View 3 & 4. Lt hz on View 1, 2, 3. View 4 real clear, snow on View 4. A low cl on 4 north & east. Sunny with breeze from SW. Some gusts.

0930 - Cl on H all views. Lt hz. View 1, 2, 3. View 4 clear. Light breeze and sunny. No dust at all from C-b work site, or from Ca either.

1030 - View 4 clearest I have ever seen. Cl on horizon View 1, 2, 3. Lt hz View 1 & 2. Sunny with breeze & some gusts from SW.

1130 - Cl on Horizon, View 1, 2, 3. View 4 real clear. Lt hz on 1 & 2. 3 is not bad. Sunny, light wind and some gusts.

1300 - Clear H on View 3. Lt hz View 1 and 2. View 3 and 4 clear. Almost a cloudless day - sunny - some wind and gusts.

1400 - No cl on H all views. View 1 light hz. View 2, 3, 4 are clean. Breeze blowing from W with some gusts. Clear & sunny.

1500 - No cl on H all views. Lt hz in west, cleaner to the east. Wind almost calm. Real nice day.

Depart site 1510

5/18/78

MST

0800 - Skiff of snow on ground at site. Breeze from west, cool, scattered clouds. Some sunshine. View 1, 2, 3 visible, hz to the northwest. View 4 in clouds. Road has been graded.

0830 - View 1, 2, 3 visible, some hz. Cl on 4. All views - scattered cls some sun, breeze (cool) from west.

0930 - All views visible. Lt hz in east to considerable amounts in west — snow on View 4. Scattered cl, some sun.

1030 - Same as 0930 but a little more wind. Some gusts.

1130 - Quite a bit of hz to the west and clear to the east. Mostly overcast with shadows from sun. Lt breeze from W.

1300 - Not much change.

1400 - Overcast at site, with shadows View 3 & 4. Lt. breeze with gusts.

1500 - View 4 in sunshine, overcast rest of views. Not much haze as wind is stronger now.

Depart site 1510

SITE LOG SHEETS

5/24/78

MST

0800 - Only 2 cl in sky - wind from SE? Quite a bit of haze seems heaviest to the NW.

0830 - Heavy Hz on View 1 & 2. Moderatge hz on View 3 & 4. View 4 has snow. Windy - out of SE. Sunny. Sometimes gusty.

0930 - Note quite as hazy as 0830 still windy. Not much change.

1030 - View 4 is clearing up. Must be the wind. Still hard to see View 1. Windy from SE with some good gusts. Sunny & nice.

1130 - Same as 1030, but starting to get some scattered clouds mostly north.

1300 - Fairly clear to the east but gets hazy to a point in where you can hardly see View 1. Wind is shaking the shelter? Real gusty. Quite a few clouds from the south.

1400 - Real hazy View 1, View 2 not quite so bad, light hz. View 3, to almost clear View 4. Windy, clouds are making some shadows.

1500 - Same as 1400 - However cl are no on H on View 1, 2, 3, very windy day storm moving in from NW.

Depart Site 1515

SITE LOG SHEETS

5/30/78

MST

0755 - Pretty sunny morning. Light breeze from NE. All view visible Snow on View 4. All views lt. hz.

0830 - No cl or H View 1 & 2, 4, cl or h View 3, sunny with breeze from NW. Seems to be more hz in the NE than even before. Snow on View 4.

0930 - Weather about the same. No cl on h now. Some cl to the north. Light hz all views.

1030 - Not much change. View 4 may be a bit clearer. Seems like more hz in area of Rio Blanco.

1130 - Cloudy to the east. Wind from west. Lt hz all views. Cool outside.

1300 - Wind from NW. Cloudy over much of the south and east. View 4 much clearer and View 1 has more hz.

1400 - Overcast - some shadows. Cl on 4. All views moderate hz to the west to lt hz in the East. Still windy looks like some showers to the East.

1500 - Overcast - generally cloudy everywhere. Still windy getting pretty hazy in the east, View 4.

Depart site 1510

SITE LOG SHEETS

10/05/78

MST

0755 - Sunny morning. Calm. All views visable.

0830 - No CL. on H. Sunny & no haze. Calm.

0930 - Some clouds on Hor. to N. but not in picture area. Slight haze all views. Slight wind from east.

1030 - Same as at 0930. Still some haze. Wind now in west. Slightly cooler.

1130 - Some clouds on H. - N.W., but not in picture area. Slight haze all views. Wind from west.

1300 - CL. on H. views 1,2,4. Haze still exists. Wind from west. More haze on views 1 & 2.

1400 - CL on H. views 1,2,3. Haze still exists. Wind from N.W.

1500 - CL. on H. views 1,2,3,4. Has been a nice day.

1510 - Departed site.

10/11/78

MST

0800 - Arrived on sight. CL. on Hr. sights 1,2,3,4. Calm & warm. All views visable but haze on all sights.

0830 - CL. on Hr all views. Still sunny & warm. No wind.

0930 - More CL. on views 1,2,3. Not yet heavy on view 4. No wind. some haze. Looks like change of weather from N.W.

1030 - About same as 0930. Clouds slowly rising. Still no wind.

1130 - Getting quite a lot of haze, views 1,2,3. Breeze blowing from N.W. CL on Hr all views. Very clear south & east.

1300 - Haze has lifted. All sights still CL. on Hr, but clouds more broken. Slight breeze from N.W.

1400 - Clouds more broken. Haze has lifted. CL on Hr. Wind from N.W. Sunny & warm.

1500 - Some CL. on Hr. Views 1,2,4. Clear on view 3. Wind stronger. Still warm & sunny.

1510 - Departed site.

SITE LOG SHEETS

10/17/78

MST

0800 - Arrived at sight. Cloudy all directions. Sights are visable, but all have haze.

0830 - Cloudy all directions. All sights barely visable. Southeast wind. All sights have haze.

0930 - Same as at 0830. No wind. #4 barely visable.

1030 - Some broken clouds overhead. Still cloudy to sights. Wind from south.

1130 - Clouds more broken. All sights, clouds and haze. Wind stronger from south.

1300 - Variable high cloudiness. Haze on sights 1,2,3. Cannot see #4. Wind stronger from south.

1400 - Seems darker all sights. But high clouds so that all sights are visable.

1500 - About the same. More haze in picture areas. Wind strong.

1507 - Dearted site.

10/23/78

MST

0800 - Arrived on sight. Sunny & very clear to views 1 & 2. Views 3 & 4 cannot see due to low clouds. No wind. Cloudy to N & W.

0830 - Very clear, views of 1 & 2. Views 3 & 4 still covered with clouds. No wind.

0930 - Same as at 0830. Slight breeze from east.

1030 - Sights 1 & 2 still very clear. #3 can now be seen under clouds. #4 still covered with clouds. Clouds seem to be breaking up.

1130 - All sights now visable. Some haze on view 1. View 4, snow on peak.

1300 - Slight haze, views 1 & 2. Views 3 & 4 extremely clear. Slight breeze from west.

1400 - Same as at 1300. Slight breeze from west. Seems some cooler. Some haze #3 & 4. (No heat in shelter)

1500 - All locations very clear. Very nice day. Sunny & cool.

1510 - Departed site.

10/29/78

MST
0810 - Arrived at sight. All sights very clear. Sunny & Bright. Moderate wind from S.E.

0830 - Conditions same. Slight haze views 1 & 2. Views 3 & 4 very clear. Wind from S.E. cool. (No heat at location)

0930 - Same as at 0830. Wind much stronger.

1030 - More haze, views 1,2,3. Quite clear on view 4. Still very windy. A few high clouds forming.

1130 - More haze, all four locations. Very windy.

1300 - Still haze, all four locations. Strong & gusty wind from S.E.

1400 - CL. on Hr views 1,2,3. Haze on view 4. Strong wind from S.E.

1500 - Cl. on Hr. Views 1,2,3. Haze on view 4. Wind still strong from S.E.

1515 - Departed site.

11/04/78

MST

0800 - Arrived at sight. Some high clouds. No wind. Light clouds all directions (trying new equipment today). Conditions same. Light clouds all directions. But sights are visable.

0930 - Condition same. Little more haze. Slight breeze from S.E.

1030 - Light clouds & haze, views 1 & 2. A little less haze, views 3 & 4. Slight breeze from S.E.

1130 - Conditions same. Clouds in background, all locations. Views 1 & 2 more haze. Wind has gotten stronger.

1300 - High clouds & haze, views 1,2,3. Clearer on view 4. Conditions about same all day.

1400 - Conditions same. Wind has let up some.

1500 - Haze has lifted some. High clouds on all locations. Conditions have remained same all day.

Tried new equipment today. Am sure I need more instruction. No consistancy to readings.

1515 - Departed site.

SITE LOG SHEETS

11/10/78

MST

0800 - Arrived at sight. Snowing lightly. Light snow cover at sight. No sights are visable.

0830 - Conditions same. Light snow. No wind. Visability about 2 miles.

0930 - Visability has lifted some. Still no sights visable. Not snowing at present.

1030 - Little more visability. No sights yet visable.

1130 - Clouds all locations. Getting much colder.

1300 - Cloudy views 1-2-3. View 4 barely visable - (Tested this view with new instrument). First reading I have taken today. View 4 only.

1400 - CL views 1-23. #4 barely visable. Took reading on instrument view, 4 only.

1500 - Cloudy. Conditions same as at 1400. Reading of new instrument on view 4 only.

This has been a cloudy, cold day.

1515 - Departed site.

11/16/78

MST

0810 - Arrived at sight. About 8" of snow on ground. Completely socked in. Visibility all directions about 100 yards. No wind.

0830 - Conditions same.

0930 - Conditions same.

1030 - Fog has lifted some. Visibility now about ½ mile.

1130 - Still no sights visable. Visability about 1 mile. No wind.

1300 - Visibility much greater. Still no sights visable. No wind. Partly cloudy.

1400 - Conditions about same as at 1300. View #4 slightly visable. CL on Hr. all directions.

1500 - CL obstruct views 1-23. #4 slightly visable. View 4 is only time I could take reading on new instrument.

Has been a cold day. No wind. Departed sight 1520.

SITE LOG SHEETS

11/22/78

MST

0820 - Arrived a little late. Slipped off road on way in. Snowing hard at present. About 1 inch of new snow on ground. Looks like it will be another bad day.

0830 - Conditions same. Snowing hard. Visability about ½ mile all directions. Slight wind from S.E.

0930 - Still snowing, but is clearing. Some blue sky overhead. Slight wind from south.

1030 - View #1 not visable. Views 2-34 barely visable. Wind strong from south. Very cold. No haze in clearing areas.

1130 - Views 1 & 2-4 not visable. View 3 is visable. Cloudy all directions. Strong wind from south. Cold.

1300 - Views 1 & 2 not visable. Snowing to the west & N.W. Views 3 & 4 visable with clouds overhead. Wind is strong from south with some drifting now to 2'.

1400 - All sights visable with background & HR of clouds. Still very windy and cold.

1500 - All sights visable. CL on HR. No haze but clouds all around. Windy and cold.

1520 - Departed site.

11/28/78

MST

0800 - Snowing lightly. Completely overcast. About 6" new snow on ground. Cold wind from south.

0830 - Snowing harder. Visability about ½ mile. Completely overcast. About a foot of snow on ground.

0930 - Conditions same. Snowing. Wind from south. Looks like another bad day. "4th day in a row."

1030 - Snowing very light. No sights yet visable. Wind strong from south. Cloud cover not so heavy now.

1130 - No sights yet visable. Strong wind from south and very cold.

1300 - No sights visable. Snowing lightly again. Wind strong. Extremely cold.

Because of poor visibility - blowing and drifting snow - decided to leave now rather than take a chance on getting caught in worse weather.

1345 - Departed site.

Table A6.3.1-1

UNIVARIATE TIME SERIES ANALYSIS FOR TEMPERATURE

Station AB23

Parameter:	Temperature (41 monthly data points)
Series Mean:	6.04651
Series Variance:	68.3787
Trend:	0 at 95% confidence level
Series Minimum:	-5.0
Series Maximum:	21.0
Chi-Sq. for Data:	232.294 with 41 d.f.
Chi-Sq. at 95% Level:	60.561 with 41 d.f.

Model: (12,0,0)	$(1-0.089864B - 0.84552B^{12})(z_t-6.04651) = a_t$
Coef. of Det:	0.849677
Residual Mean:	0 at 95% confidence level
Residual Variance:	
Residual Minimum:	
Residual Maximum:	
Residual Chi-Sq.:	9.86816 with 45 d.f.
Chi-Sq. at 95% Level:	61.656 with 45 d.f.

Discussion: This is an ARIMA (12,0,0) model where 12 = the order of the autoregressive terms, 0 = the order of the difference term (there is no differencing), and the last 0 = the order of the moving average terms (there are no moving average terms). The trend was not significant at the 95% confidence level. Although the chi-square statistic for the data is significant at the 95% level, the residual chi-square is not significant, indicating that the residuals have been reduced to uncorrelated white noise. The partial autocorrelation function of the actual data had significant spikes at lags 1, 2, 3, and nine. Insignificant parameters were discarded to obtain the current model which fits the data well and accounts for an annual cycle of 12 months.

NOTE: See Appendix A5.2.1D for discussion of Univariate Time Series Analysis.

TABLE A6.3.1-2

AIR TEMPERATURE, 10m (^{o}C)

STA.	ITEM	SEASONAL YEAR	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	ANN. MAX. AVG. MIN.
AB20	HOURLY MAX.	1975	7	10	8	15	21	26	31	32	31	28	25	18	32
AB23	" "	1975	9	6	6	10	20	22	28	29	28	26	22	17	29
AB20	HOURLY AVG.	1975	-11	-9	-7	0	2	9	14	19	17	12	6	-3	4
AB23	" "	1975	-4	-5	-4	-1	2	8	13	19	18	13	8	0	6
AB20	HOURLY MIN.	1975	-34	-43	-31	-33	-28	-9	-1	6	-2	-8	-18	-27	-43
AB23	" "	1975	-18	-21	-18	-21	-14	-6	1	11	4	-2	-10	-16	-21
AB20	HOURLY MAX.	1976	11	8	11	13	20	27(1)	30	34	31	30	25	(2)	34
AB23	" "	1976	10	8	9	11	17	23	28	31	27	27	22	15	31
AB20	HOURLY AVG.	1976	-6	-9	-3	-4	4	11	15	21	18	13	3	(2)	
AB23	" "	1976	-2	-4	-1	-2	6	11	16	21	18	13	6	1	7
AB20	HOURLY MIN.	1976	-26	-41	-29	-32	-9	-7(1)	-8	4	1	-4	-14	(2)	-41
AB23	" "	1976	-14	-21	-14	-15	-6	-3	-6	10	6	2	-9	-19	-21
AB20	HOURLY MAX.	1977													
AB23	" "	1977	8	7	12	12	19	22(1)	28(1)	28(1)	29	34	22	18	34
AB20	HOURLY AVG.	1977													
AB23	" "	1977	-3	-5	-2	-2	6	9(1)	20(1)	21(1)	19	15	5	3	7
AB20	HOURLY MIN.	1977													
AB23	" "	1977	-13	-20	-13	-16	-11	-2(1)	7(1)	11(1)	3	-4	-12	-17	-20
AB20	HOURLY MAX.	1978								(2)	29	27			
AB23	" "	1978	13	13	6	15	18	24	28	31	29	28			31
AB20	HOURLY AVG.	1978								(2)	17	14			
AB23	" "	1978	4	7	-3	2	6	9	17	21	18	15			
AB20	HOURLY MIN.	1978								(2)	2	-4			
AB23	" "	1978	-8	-2	-15	-11	-5	-4	2	7	2	-3			-15

(1) Partial Data Only

(2) Station Inoperative

TABLE A6.3.1-3

GROWING SEASON AND DEGREE-DAYS BY YEAR

YEAR	GROWING SEASON*			DEGREE-DAYS** (^{0}C-DAYS) IN				
	START	STOP	LENGTH (days)	GROWING SEASON	APR-MAY-JUN	MAY-JUN-JUL	JUN-JUL-AUG	JUL-AUG-SEPT
1975	May 26	Sept 21	118	84	8	57	84	76
1976	June 14	Oct 5	111	111	15	87	108	93
1977	Apr 21	Sept 14	144	110	23	70	110	87
1978	May 15	Sept 17	124	223	33	121	169	163

* Hourly minimum air temperature always $>0^{0}$C

** $\frac{5}{9}\left[T_{av} - 65^{0}F\right]$ X (No. of days in month for which T_{av} applies) Summed over appropriate number of months

Where T_{av} = daily average temperature (^{0}F) specifically for those days whose average is over 65^{0}F

(Ref: Munn (1970))

TABLE A6.3.1-4

DIRECT SOLAR RADIATION

MONTH	TOTAL LANG. FOR MONTH UNMOD.	MOD.*	AVG. DAY-LIGHT HRS/DAY	DAYLIGHT HRS PER MONTH	UPTIME DAYLIGHT HRS/MO.	CORR. FACTOR = ⑤/⑥	AVG. LANG/DAY (MOD.)	DAILY TOTAL/DATE HIGHEST	LOWEST
①	②	③ = ② x ⑦	④	⑤	⑥	⑦	③/(Days Per Mo.)	⑨	⑩
11/74	4121	4256	10	300	291	1.031	141.9	225/11	1/3
12/74	1878	3500	10	310	167	1.856	112.9	164/9	0/7
01/75	4036	4396	10	310	284	1.092	141.8	266/1	22/28
02/75	6880	7305	11	308	291	1.058	260.9	416/24	100/15
03/75	7586	10076	12	372	280	1.329	325.0	479/19	142/9
04/75	10940	11325	13	390	375	1.040	377.5	550/25	65/7
05/75	14559	14559	14	434	434	1.000	496.6	706/26	94/28
06/75	13762	15667	15	450	395	1.139	522.2	737/26	166/18
07/75	16079	16659	15	465	447	1.040	537.4	687/6	227/16
08/75	15005	15870	14	434	409	1.061	511.9	665/3	324/13
09/75	11849	12324	13	390	375	1.040	410.8	545/6	180/11
10/75	10089	10114	12	372	372	1.000	326.3	446/1	28/31
11/75	4615	4670	10	300	297	1.010	155.7	279/1	11/28
12/75	3957	4007	10	310	307	1.010	129.3	207/18	13/25
01/76	6166	6176	10	310	310	1.000	199.2	303/29	85/5
02/76	8102	8102	11	308	308	1.000	279.4	393/22	59/6
03/76	11856	12046	12	372	365	1.019	388.6	567/30	133/25
04/76	11990	13225	13	390	355	1.099	440.8	656/28	187/17
05/76	14693	15198	14	434	421	1.031	490.3	732/16	224/6
06/76	18674	18689	15	450	450	1.000	623.0	741/21	227/22
07/76	17102	17292	15	465	460	1.011	557.8	720/4	229/5
08/76	15351	15961	14	434	417	1.041	514.9	665/5	193/1
09/76	11477	11477	13	390	390	1.000	382.6	558/2	155/24
10/76	10178	10178	12	372	372	1.000	328.3	440/7	143/26
11/76	6725	6725	10	300	299	1.003	224.9	307/1	75/13
12/76	5685	5685	10	310	310	1.000	183.4	242/1	73/5
01/77	6043	6043	10	310	309	1.003	194.9	376/25	54/5
02/77	7850	7850	11	308	308	1.000	280.4	409/27	92/22
03/77	10737	11059	12	372	360	1.033	356.7	523/27	110/17
04/77	12870	12870	13	390	390	1.000	429.0	598/10&24	90/19
05/77	16228	16390	14	434	431	1.007	528.7	717/18	209/14
06/77	18590	18590	15	450	450	1.000	619.7	744/19	381/7
07/77	14256	16124	15	465	420	1.107	520.1	731/10	269/4
08/77	13970	14249	14	434	424	1.024	459.6	674/1	172/17
09/77	11904	12380	13	390	375	1.040	412.7	568/2	121/28
10/77	9676	9870	12	372	365	1.019	318.4	667/2	89/31
11/77	5580	6026	10	300	279	1.075	200.9	323/1	36/19
12/77	1328	-	10	310	81	-	-	229/5	75/3
01/78	1147	-	10	310	98	-	-	249/13	67/18
02/78	4508	8250	11	308	168	1.833	294.6	404/18	90/3
03/78	954	-	12	372	22	-	-	101/30	67/31
04/78	-	-	13	390	-	-	-	-	-
05/78	7587	-	14	434	183	-	-	714/12	5/21
06/78	-	-	15	450	-	-	-	-	-
07/78	1835	-	15	465	55	-	-	646/30	366/29
08/78	16327	16441	14	434	431	1.007	530.4	663/3	234/14
09/78	12107	12557	13	390	376	1.037	418.6	483/22	126/18
10/78									
11/78									
12/78									

* "Modified" by the ratio of total-daylight to uptime-daylight hrs/mo for cases where uptime $\geq$ 50% of total.

TABLE A6.3.1-5

RELATIVE HUMIDITY (%)

STA.	ITEM	SEASONAL YEAR	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	ANN. MAX. AVG. MIN.
AB23	HOURLY MAX.	1975	100	100	100	100	100	100	100	100	87	93	100	100	100
AB23	HOURLY AVG.	1975	69	68	72	72	67	64	54	54	29	35	40	53	56
AB23	HOURLY MIN.	1975	25	26	32	37	32	28	25	28	12	16	15	19	12
AB23	HOURLY MAX.	1976	90	90	89	30	98	90	99	96	100	99	94	97	100
AB23	HOURLY AVG.	1976	62	62	57	56	53	51	44	47	50	59	51	56	54
AB23	HOURLY MIN.	1976	34	25	22	23	21	24	27	29	32	32	32	32	21
AB23	HOURLY MAX.	1977	96(1)	(2)	(2)	74(1)	100	(2)	80	(2)	(2)	99(1)	(2)	(2)	100
AB23	HOURLY AVG.	1977	58(1)	(2)	(2)	56(1)	67	(2)	24	(2)	(2)	37(1)	(2)	(2)	(1)
AB23	HOURLY MIN.	1977	30(1)	(2)	(2)	41(1)	37	(2)	1	(2)	(2)	15(1)	(2)	(2)	1
AB23	HOURLY MAX.	1978	99	97	96	96	95	94	96	94	94	97			99
AB23	HOURLY AVG.	1978	65	74	71	66	53	49	42	38	38	45			
AB23	HOURLY MIN.	1978	10	32	25	20	14	13	12	9	9	8			8

(1) Partial Data Only

(2) Missing Data

TABLE A6.3.1-6a
MONTHLY PRECIPITATION FOR 1975

( ) = Estimate

STATION	COM-PUTER CODE	MONTHLY TOTAL (cm)												ANN. TOTAL
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ACTUAL (EST)
USGS 022	WU22		2.54	2.74	0.71				2.87	1.22	2.54			
USGS 015	WU15		1.27	1.22	2.54	2.57	5.18	2.36	0.30	0.66	2.79	2.79	2.03	
USGS 058	WU58								1.65	1.09	2.29			
USGS 050	WU50		1.27	1.52	1.65	0.28		1.27	0.51		1.65	1.78	2.01	
USGS 070	WU70	5.74	4.01	6.78	5.21			2.54	0.43	1.02	4.85	4.95	4.01	
AQ Sta 020	AB20													
AQ Sta 023	AB23													
MC Sta 1	BC01							1.80	1.00	0.08	0.43	0.76	1.15	
MC Sta 2	BC02							1.80	0.80	0.20	0.41	1.42	1.35	
MC Sta 3	BC03					2.62	2.49	0.60	0.40	1.19	0.46	1.27	1.15	
MC Sta 4	BC04					2.59	4.62	2.50	1.00	0.36	0.50	1.14	1.52	
MC Sta 5	BC05						2.18	1.30	1.10	0.13	0.10	2.49	1.10	
MC Sta 6	BC06					3.40	6.99	2.40	0.70	0.61	0.48	3.07	1.37	
MC Sta 7	BC07					0.53	3.28	4.60	0.40	0				
MC Sta 8	BC08					0.64	1.52	3.20	0	0	0			
MC Sta 9	BC09						3.05	1.00	3.40	0.86	0.43	0.97	1.50	
MC Sta 13	BC13					5.59	3.30	3.10	4.30	0.03	0.66	1.50	1.65	
AVERAGE*		(1) (2.42)	1.66	1.83	1.63	2.28	3.62	2.16	1.32	0.49	0.98	1.72	1.48	(24.86)
AVERAGE EXCL. MC		(2.42)	1.69	1.83	1.63	1.43	5.18	1.82	1.33	0.99	2.32	2.29	2.02	(24.95

(1) Estimated "Tract" average from ratio of WU70 to the average of WU15, WU50, and WU22 for the month of February, i.e.:

$$5.74 \times \frac{1.69}{4.01} = 2.42$$

*EXCL WU70

TABLE A6.3.1-6b
MONTHLY PRECIPITATION FOR 1976

( ) = Estimate

STATION	COM-PUTER CODE	MONTHLY TOTAL (cm)												ANN. TOTAL ACTUAL (EST)
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
USGS 022	WU22					4.06	2.01	4.24	2.26	2.79	0.51			
USGS 015	WU15		4.06	4.29	1.78	3.05	2.01	2.92	0.13	2.46		0.10	0	
USGS 058	WU58						2.90	4.09	1.12					
USGS 050	WU50		4.32	4.32	1.65	3.48	1.60	2.41	Tr.	2.03		0	0	
USGS 070	WU70	1.47	8.71	5.82				4.62	1.68	4.29	1.47	0.79	0.84	
AQ Sta 020	AB20												0.74	
AQ Sta 023	AB23												0.99	
MC Sta 1	BC01	3.90		4.10		0.79	0.97	0	1.30		0.66			
MC Sta 2	BC02	3.40		4.60		1.52	1.80	0	0.76		0			
MC Sta 3	BC03	4.13	4.60	9.22	4.90	6.30	1.63	1.63	1.30			0.11	0	
MC Sta 4	BC04	2.29	2.48	0	0		1.88	0.36	1.47	0.79	0	0	0	
MC Sta 5	BC05	4.30	3.09	3.20		0.97	0.91	0.20	0.71		2.87	0.43		
MC Sta 6	BC06	2.20	0.99	2.63	0.79	1.68	2.29	3.56	0.56	0.91	2.14			
MC Sta 7	BC07	2.20	1.41						1.78	0.72		0.86		
MC Sta 8	BC08	1.10	0.64	2.40	2.16	0.91	1.57	1.32	1.55					
MC Sta 9	BC09	2.00	4.19	2.90		2.01	0.74	0.25	1.73					
MC Sta 13	BC13	3.10	2.59	4.80		1.19	1.37	0.25	1.73					
AVERAGE*		2.86	2.84	3.86	1.88	2.30	1.67	1.63	1.17	1.62	1.03	0.25	0.29	(21.46)
AVERAGE EXCL. MC		0	4.19	4.31	1.72	3.53	2.13	3.42	0.87	2.43	0.51	0.10	0.43	(23.64)

*EXCL WU70

TABLE A6.3.1-6c
MONTHLY PRECIPITATION FOR 1977

( ) = Estimate

STATION	COM-PUTER CODE	MONTHLY TOTAL (cm)												ANN. TOTAL ACTUAL (EST)
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
USGS 022	WU22					2.03	0.28	6.05	6.50	5.84	2.84			
USGS 015	WU15	1.09	0.38	2.9	0.53	1.85	0.08	5.05	5.18	3.40	2.84	4.22		
USGS 058	WU58					2.36	0.51	1.68	6.15	5.14	1.55			
USGS 050	WU50	1.09	0.30	2.18	1.70	2.34	0.25	4.17	5.36	2.83	1.32	4.29	2.74	
USGS 070	WU70	1.98	1.70	7.39		3.40	0.28	1.52	6.05	3.71	2.36	4.98	3.28	
AQ Sta 020	AB20	2.31	1.19	4.24	3.15	2.39	0.38	3.91	5.18	9.27	2.57	4.37	3.43	
AQ Sta 023	AB23	2.03	1.35	4.01	3.18	2.79	0.41	4.70	5.66	3.73	2.24	3.66	2.16	
MC Sta 1	BC01										4.32	0.86		
MC Sta 2	BC02										1.90	0.56		
MC Sta 3	BC03	0.05	0.03	0.04	0.15	0.03	0.02	17.80			4.70	1.02		
MC Sta 4	BC04	0.04	0.03	0.06	0.13	0.10	0.03				2.79	0.74		
MC Sta 5	BC05										2.16	0.36		
MC Sta 6	BC06	0.12	0	0.03	0.09	0.08	0	8.72			3.91	0.97		
MC Sta 7	BC07	0	0	0	0.38	0.25					1.52	0.66		
MC Sta 8	BC08										4.44	0.63		
MC Sta 9	BC09										1.47	0.46		
MC Sta 13	BC13										4.01	1.14		
AVERAGE*		0.84	0.41	2.08	0.88	1.42	0.22	6.51	5.67	5.04	2.79	1.71	2.78	(30.35)
AVERAGE EXCL. MC		2.21	0.81	3.33	2.14	2.75	0.38	4.26	5.67	5.04	2.23	4.14	2.78	(35.74)

*EXCL WU70

TABLE A6.3.1-6d
MONTHLY PRECIPITATION FOR 1978

( ) = Estimate

STATION	COM-PUTER CODE	MONTHLY TOTAL (cm)												ANN. TOTAL ACTUAL (EST)
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
USGS 022	WU22						0	1.40	0.53	1.02				
USGS 015	WU15	2.67	2.08	7.37	0	1.57	0.05	1.78	0.79	3.23	0	4.83		
USGS 058	WU58						0.71	0.43	0.46					
USGS 050	WU50	1.93	1.57	5.79	0	1.68	0.05	2.77	0.64	1.27	0	3.89		
USGS 070	WU70	4.88			3.51	3.38	1.03	3.22	1.50	0.97	0.86	7.90	5.89	
AQ Sta 020	AB20	3.02	2.11	8.13	1.70	3.99	2.57	2.1B	2.36	1.83	0.58	4.83		
AQ Sta 023	AB23	1.65	2.64	8.36	2.29	3.94	1.30	1.98	0.48	1.40	0.20	4.50		
MC Sta 1	BC01	6.60	6.60		7.72	2.36	2.51	1.22	0.B7	1.45	0.28	2.69	1.78	
MC Sta 2	BC02	6.86	6.86	4.14	4.75	2.18	2.67	2.57	0.94	1.52	0.10	3.76	9.98	
MC Sta 3	BC03	6.86	6.86	4.70	4.70	2.62	2.77	1.83	1.27	1.20	0	3.66	1.80	
MC Sta 4	BC04	6.60	6.60	3.56	5.31	2.44	2.84	2.06	1.12	1.35	0.10	3.55	1.57	
MC Sta 5	BC05	6.60	6.60		7.19	1.60	2.79	0.33	0.36	1.24	0.30	3.86	1.83	
MC Sta 6	BC06			4.83	5.87	2.49	2.26	0.66	1.20	1.53	0	2.85	4.95	
MC Sta 7	BC07	6.86	6.86	3.63	4.70	1.98	3.00	1.71	1.05	1.62	0.33	3.22	1.37	
MC Sta 8	BC08	6.98		3.66	3.71	1.80	3.86	0.38	0.99	1.22	1.12	3.56	1.57	
MC Sta 9	BC09	7.62		3.68	5.36	2.26	2.95	0.41	1.12	1.32	0.25	3.08	1.88	
MC Sta 13	BC13			4.19	6.10	2.59	3.05	1.43	1.47	1.62	0.25	2.87		
AVERAGE*		5.35	4.88	5.17	4.24	2.39	2.09	1.45	0.98	1.52	0.25	3.65	2.97	(34.94)
AVERAGE EXCL. MC		2.32	2.10	7.41	1.00	2.80	0.78	1.76	0.88	1.75	0.20	4.51	0	(25.51)

*EXCL WU70

TABLE A6.3.1-7

EVAPORATION (cm) @ STATION AB23

1978

	MONTH				
	MAY	JUNE	JULY	AUGUST	SEPTEMBER
PAN					
MONTHLY TOTAL	20.8	22.5	27.0	24.2	17.7
DAILY AVERAGE	0.67	0.75	0.87	0.78	0.59
LAKE(1)					
MONTHLY TOTAL	14.6	15.8	18.9	16.9	12.4
DAILY AVERAGE	0.47	0.53	0.61	0.55	0.41

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(1) Assumes a pan coefficient of 0.7

TABLE A6.3.1-8

BAROMETRIC PRESSURE, MILLIBARS (DAILY EXTREMA)

STA.	ITEMS	SEASONAL YEAR	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	ANN. MAX. AVG. MIN.
AB24	DAILY MAX.	1975						795	796	799	798	803	802	803	803(1)
AB23	" "	1975		795	794(1)	790	790	792	793	794	794	799	798	800	800
AB24	DAILY AVG.	1975						790(1)	791(1)	795	796	797	794	793(1)	
AB23	" "	1975		786	785	782(1)	782	786	778(1)	791	792	794	791	789	
AB24	DAILY MIN.	1975						776	781	792	792	792	782	772	772(1)
AB23	" "	1975		770	777	769	771	773	778	788	789	789	782	770	770
AB24	DAILY MAX.	1976	802	802	804	796	799	798	799	799	801	803	800	(3)	804
AB23	" "	1976	798	799	799	793	790	795	795	796	797	799	797	798	799
AB24	DAILY AVG.	1976	794	795	791	788	789	793(1)	793	796(1)	797	796	795	(3)	
AB23	" "	1976	791	791	788	785	786(1)	790(1)	790	792(1)	793	793	792	792	790
AB24	DAILY MIN.	1976	776	785	778	778	776	787	787	791	792	790	789	(3)	776
AB23	" "	1976	780	781	775	775	781	784(1)	784	789	787	787	786	777	775
AB23	DAILY MAX.	1977	798	797	797	793	796	795	795	797	796	(2)	(2)	(2)	798(1)
AB23	DAILY AVG.	1977	790	788	790	784	789	786	791	794	794	(2)	(2)	(2)	
AB23	DAILY MIN.	1977	779	773	774	771	775	776	786	789	789	(2)	(2)	(2)	771(1)
AB23	DAILY MAX.	1978	(2)	784(1)	788	787	771	771	795	793	796	792			796(1)
AB23	DAILY AVG.	1978	(2)	773(1)	775	777	764	764	789	787	789	785			
AB23	DAILY MIN.	1978	(2)	758(1)	760	765	757	753	782	773	776	770			753(1)

(1) Partial Data Only

(2) Missing Data

(3) Station Inoperative

APPENDIX A6.3.2

This Appendix consists of two parts:

A6.3.2A - Wind Fields Summaries

A6.3.2B - Tracer Test Results

APPENDIX A6.3.2A

Wind Fields Summaries

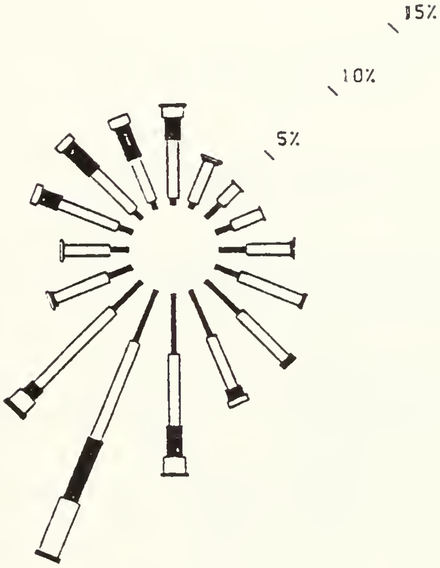
List of Figures Appearing in Appendix A6.3.2A

Figure A6.3.2A-1

Meteorological Tower Quarterly Wind Roses - 10M Level (1976-1977)

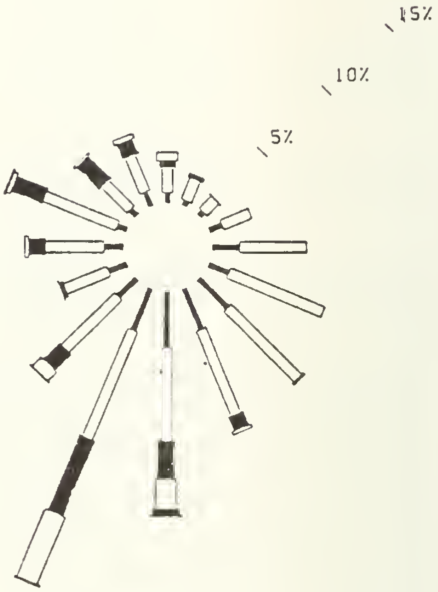
QUARTERLY WIND ROSE-10M LEVEL
SEP '76 - NOV '76

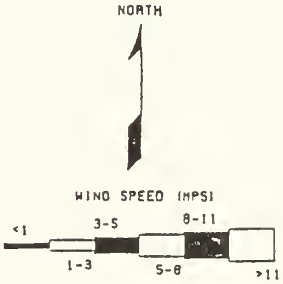
TOTAL % OF CALMS DISTRIBUTED (0.00%)
TOTAL NO. OF 1 HOUR SAMPLES -2148



QUARTERLY WIND ROSE-10M LEVEL
DEC '76 - FEB '77

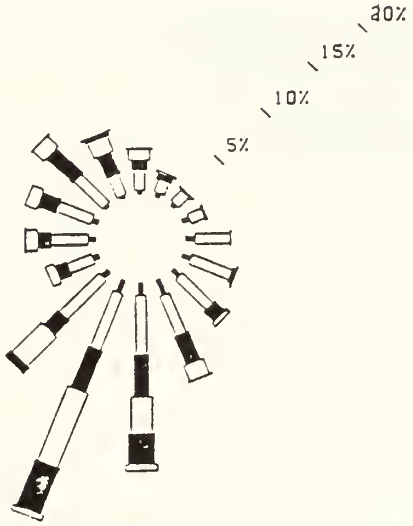
TOTAL % OF CALMS DISTRIBUTED (0.00%)
TOTAL NO. OF 1 HOUR SAMPLES -2147





QUARTERLY WIND ROSE-10M LEVEL
MAR '77 - MAY '77

TOTAL % OF CALMS DISTRIBUTED (0.00%)
TOTAL NO. OF 1 HOUR SAMPLES -2147



QUARTERLY WIND ROSE-10M LEVEL
JUN '77 - AUG '77

TOTAL % OF CALMS DISTRIBUTED (0.00%)
TOTAL NO. OF 1 HOUR SAMPLES -1573

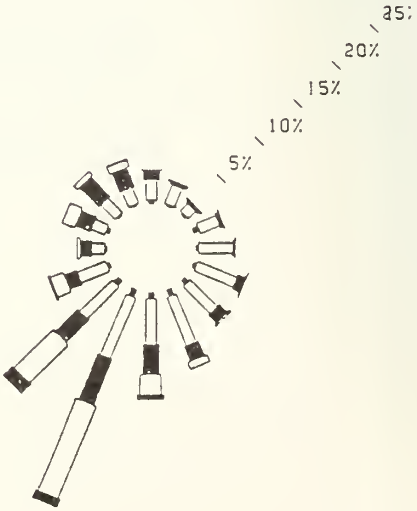
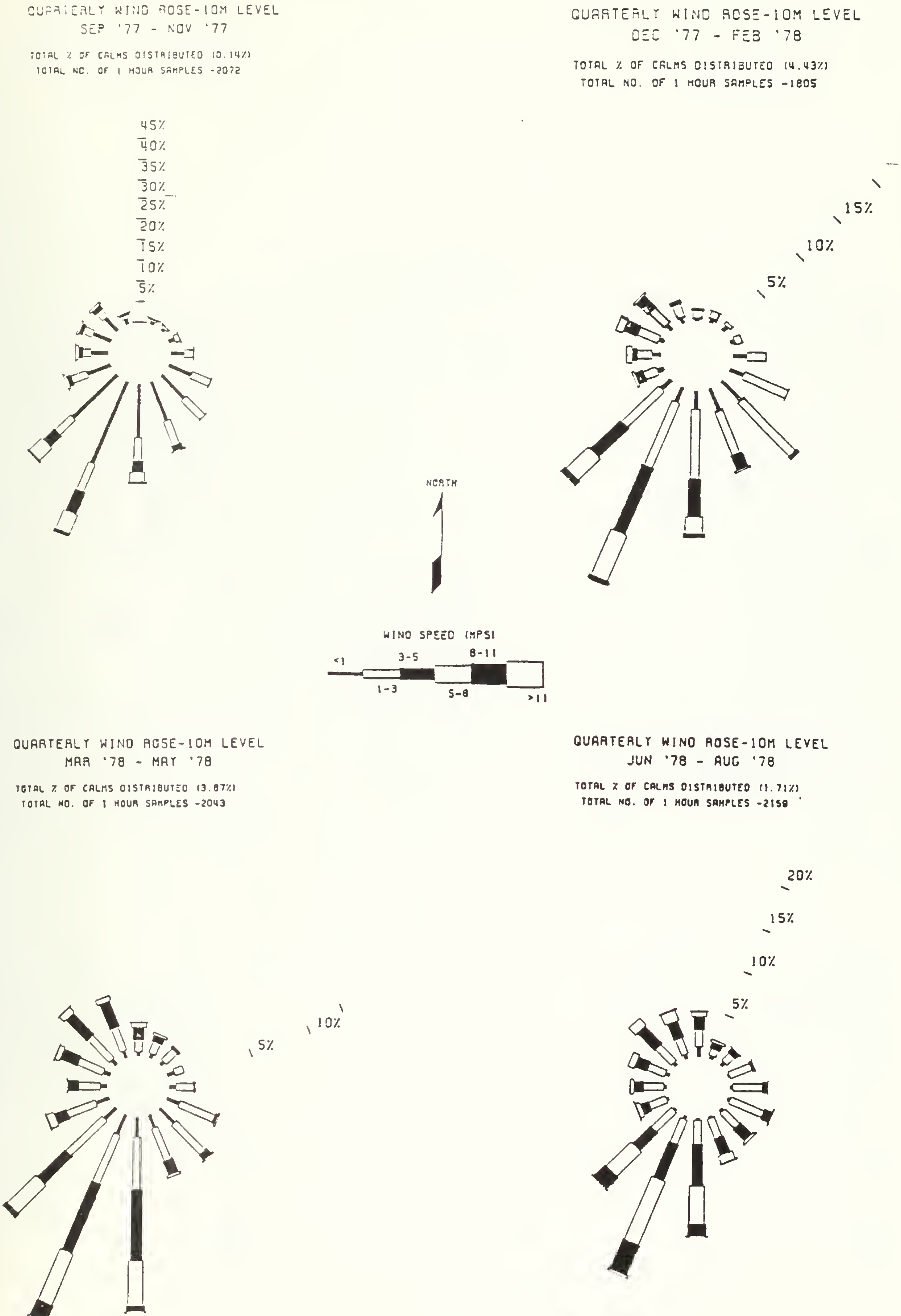


Figure A6.3.2A-2
Meteorological Tower Quarterly Wind Roses - 10M Level (1977-1978)



QUARTERLY WIND ROSE-10M LEVEL
SEP '77 - NOV '77
TOTAL % OF CALMS DISTRIBUTED (0.14%)
TOTAL NO. OF 1 HOUR SAMPLES -2072

QUARTERLY WIND ROSE-10M LEVEL
DEC '77 - FEB '78
TOTAL % OF CALMS DISTRIBUTED (4.43%)
TOTAL NO. OF 1 HOUR SAMPLES -1805

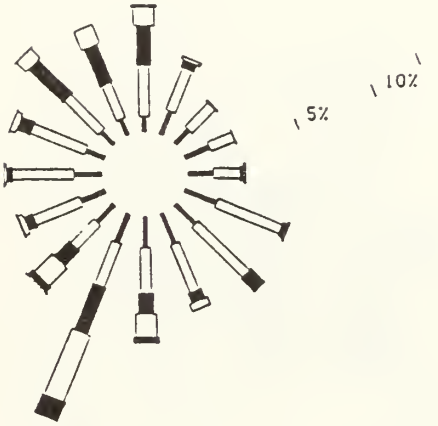
QUARTERLY WIND ROSE-10M LEVEL
MAR '78 - MAY '78
TOTAL % OF CALMS DISTRIBUTED (3.87%)
TOTAL NO. OF 1 HOUR SAMPLES -2043

QUARTERLY WIND ROSE-10M LEVEL
JUN '78 - AUG '78
TOTAL % OF CALMS DISTRIBUTED (1.71%)
TOTAL NO. OF 1 HOUR SAMPLES -2158

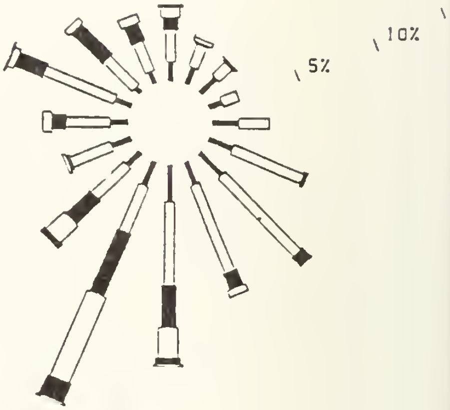
Figure A6.3.2A-3

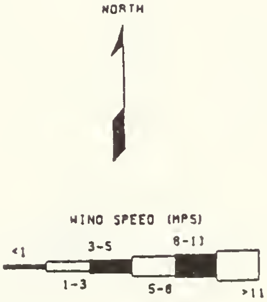
Meteorological Tower Quarterly Wind Roses - 30M Level (1976-1977)

QUARTERLY WIND ROSE - 30M LEVEL
SEP '76 - NOV '76
TOTAL % OF CALMS DISTRIBUTED (0.0 %)
TOTAL NO. OF 1 HOUR SAMPLES -2152

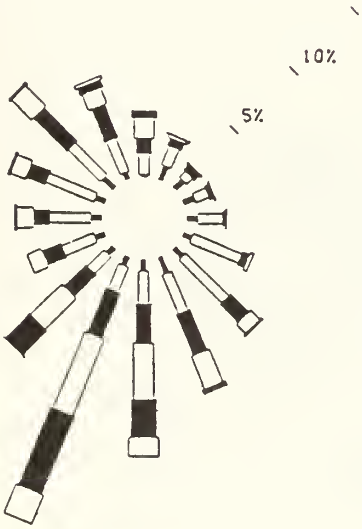


QUARTERLY WIND ROSE - 30M LEVEL
DEC '76 - FEB '77
TOTAL % OF CALMS DISTRIBUTED (0.0 %)
TOTAL NO. OF 1 HOUR SAMPLES -2145

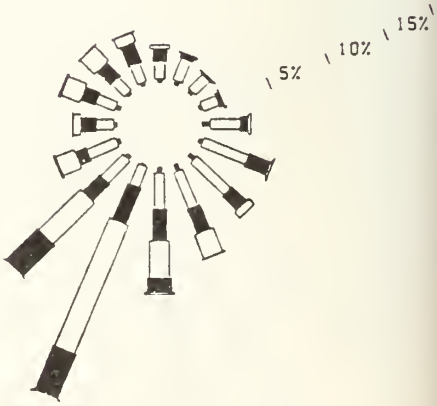




QUARTERLY WIND ROSE - 30M LEVEL
MAR '77 - MAY '77
TOTAL % OF CALMS DISTRIBUTED (0.0 %)
TOTAL NO. OF 1 HOUR SAMPLES -2162



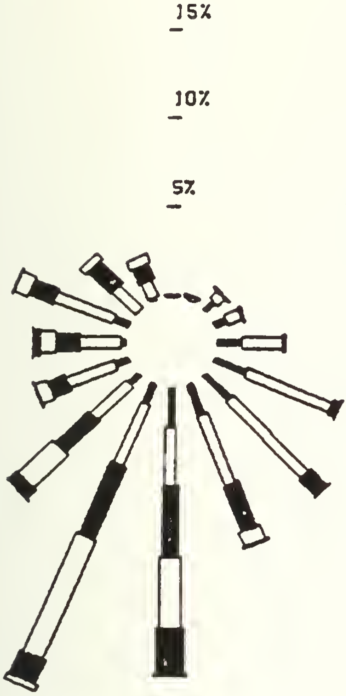
QUARTERLY WIND ROSE - 30M LEVEL
JUN '77 - AUG '77
TOTAL % OF CALMS DISTRIBUTED (0.0 %)
TOTAL NO. OF 1 HOUR SAMPLES -1334

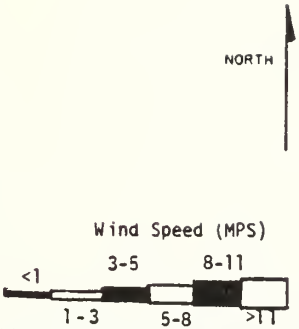


QUARTERLY WIND ROSE - 30M LEVEL
SEPT'77 - NOV'77

TOTAL % OF CALMS DISTRIBUTED (0.00%)

TOTAL NO. 1 - HR SAMPLES (2075)

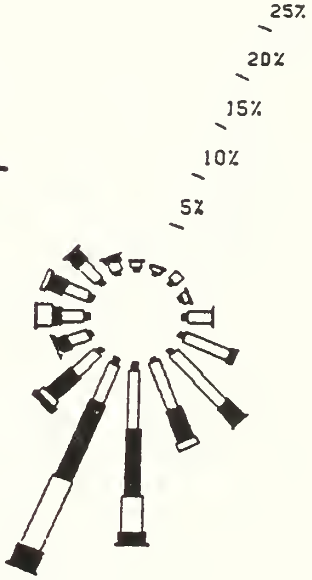




QUARTERLY WIND ROSE - 30M LEVEL
DEC'77 - FEB'78

TOTAL % OF CALMS DISTRIBUTED (3.73%)

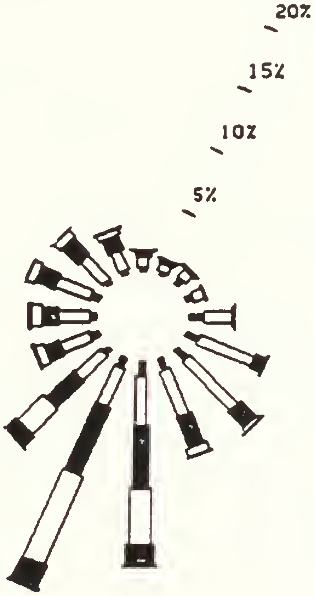
TOTAL NO. 1 - HR SAMPLES (1770)



ANNUAL WIND ROSE - 30M LEVEL
SEPT'77 - AUG'78

TOTAL % OF CALMS DISTRIBUTED (2.24%)

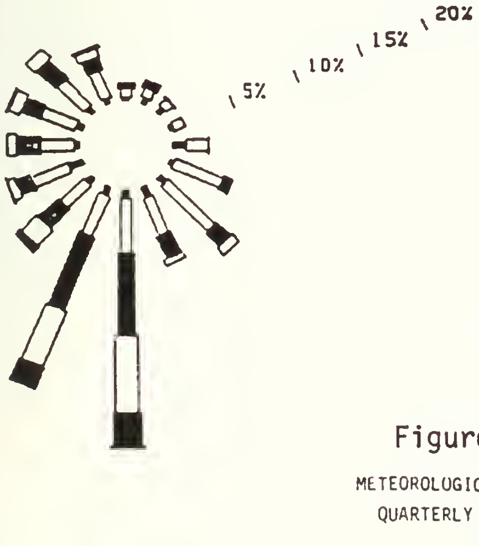
TOTAL NO. 1-HR SAMPLES (7335)



QUARTERLY WIND ROSE - 30M LEVEL
MAR'78 - APR'78

TOTAL % OF CALMS DISTRIBUTED (4.20%)

TOTAL NO. 1 - HR SAMPLES (1333)



QUARTERLY WIND ROSE - 30M LEVEL
JUNE'78 - AUG'78

TOTAL % CALMS DISTRIBUTED (1.95%)

TOTAL NO. 1 - HR SAMPLES (2158)

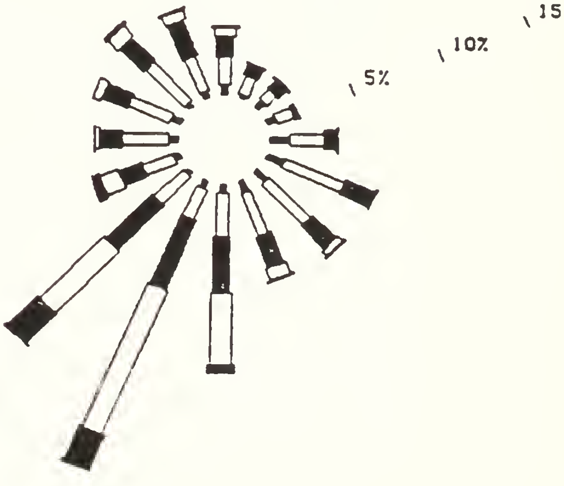


Figure A6.3.2A-4

METEOROLOGICAL TOWER 30M ELEVATION
QUARTERLY AND ANNUAL WIND ROSES
1977 - 1978

Figure A6.3.2A-5

Station AB20 Quarterly Wind Rose - 10M Level (1976)

AB20 QUARTERLY WIND ROSE @10M
SEP '76 - OCT '76

TOTAL % OF CALMS DISTRIBUTED (0.0 %)
TOTAL NO. OF 1 HOUR SAMPLES -1401

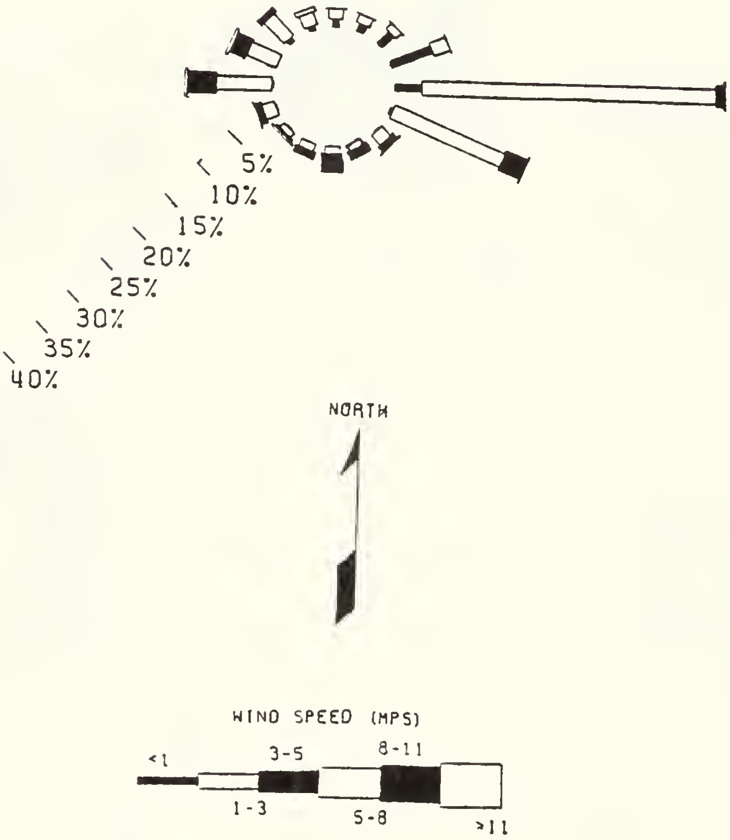
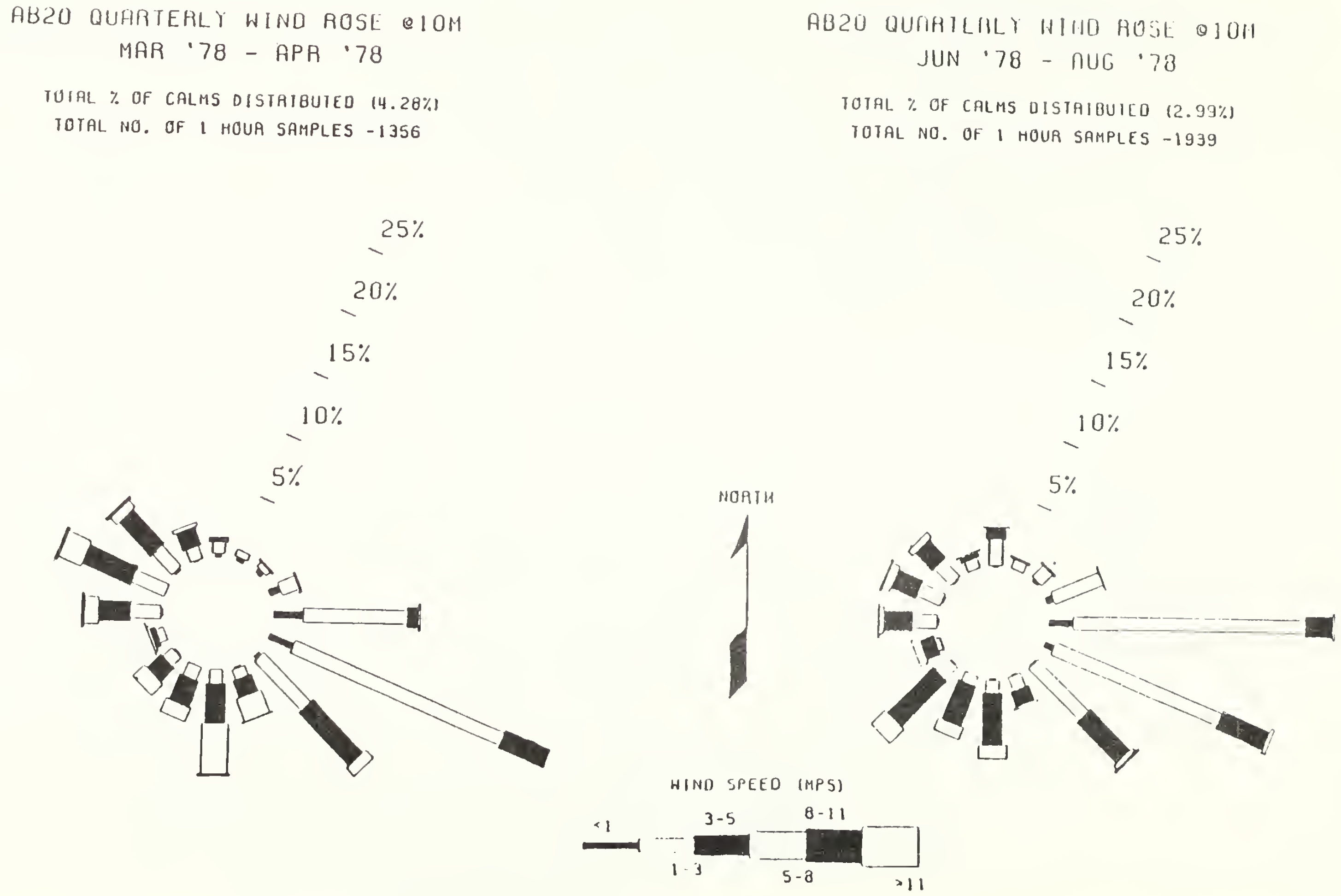


Figure A6.3.2A-6

Station AB20 Quarterly Wind Rose - 10M Level (1978)

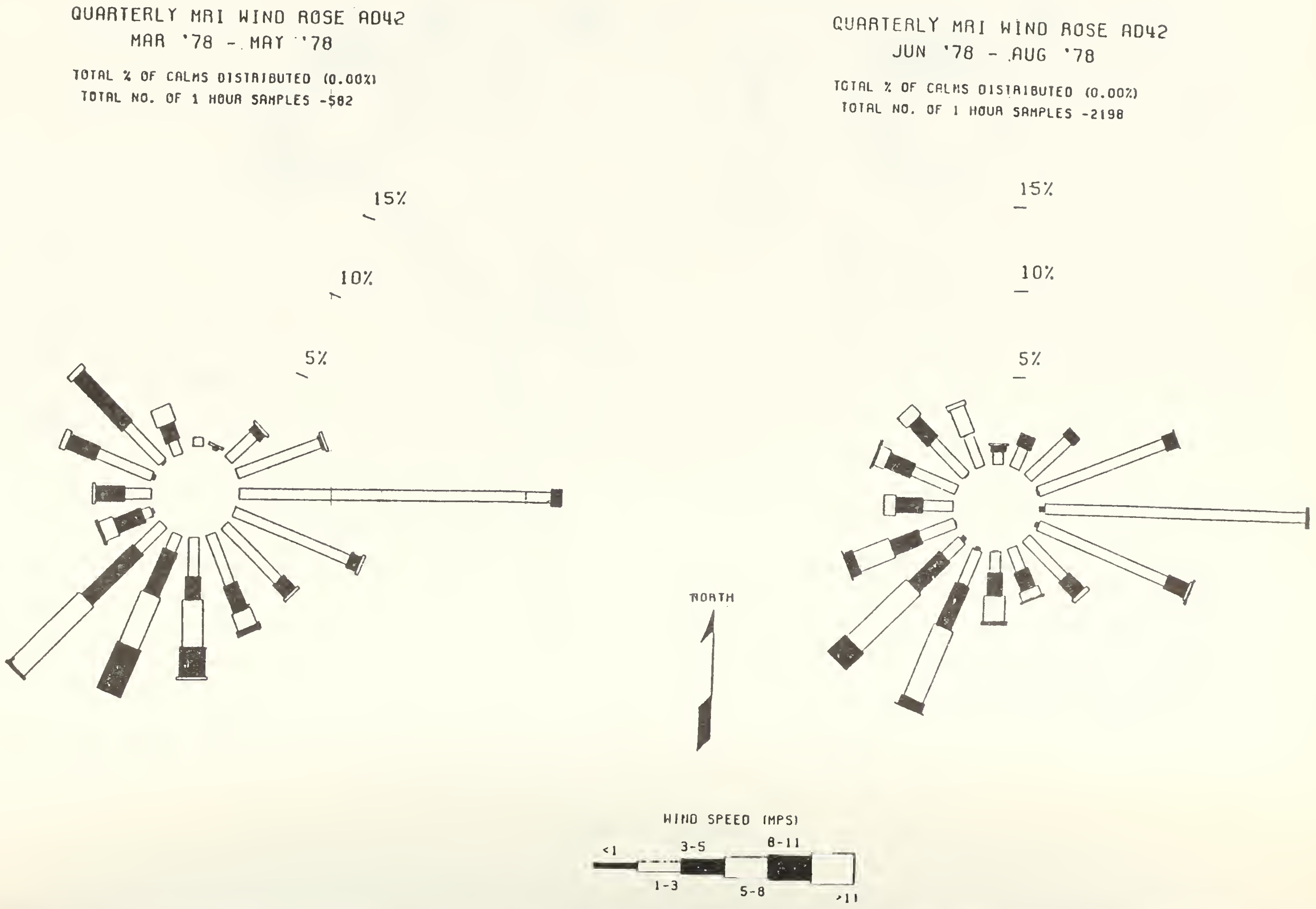


AB20 QUARTERLY WIND ROSE @10M
MAR '78 - APR '78
TOTAL % OF CALMS DISTRIBUTED (4.28%)
TOTAL NO. OF 1 HOUR SAMPLES -1356

AB20 QUARTERLY WIND ROSE @10M
JUN '78 - AUG '78
TOTAL % OF CALMS DISTRIBUTED (2.99%)
TOTAL NO. OF 1 HOUR SAMPLES -1939

Figure A6.3.2A-7

Station AD42 Quarterly MRI Wind Roses - 10M Level (1978)

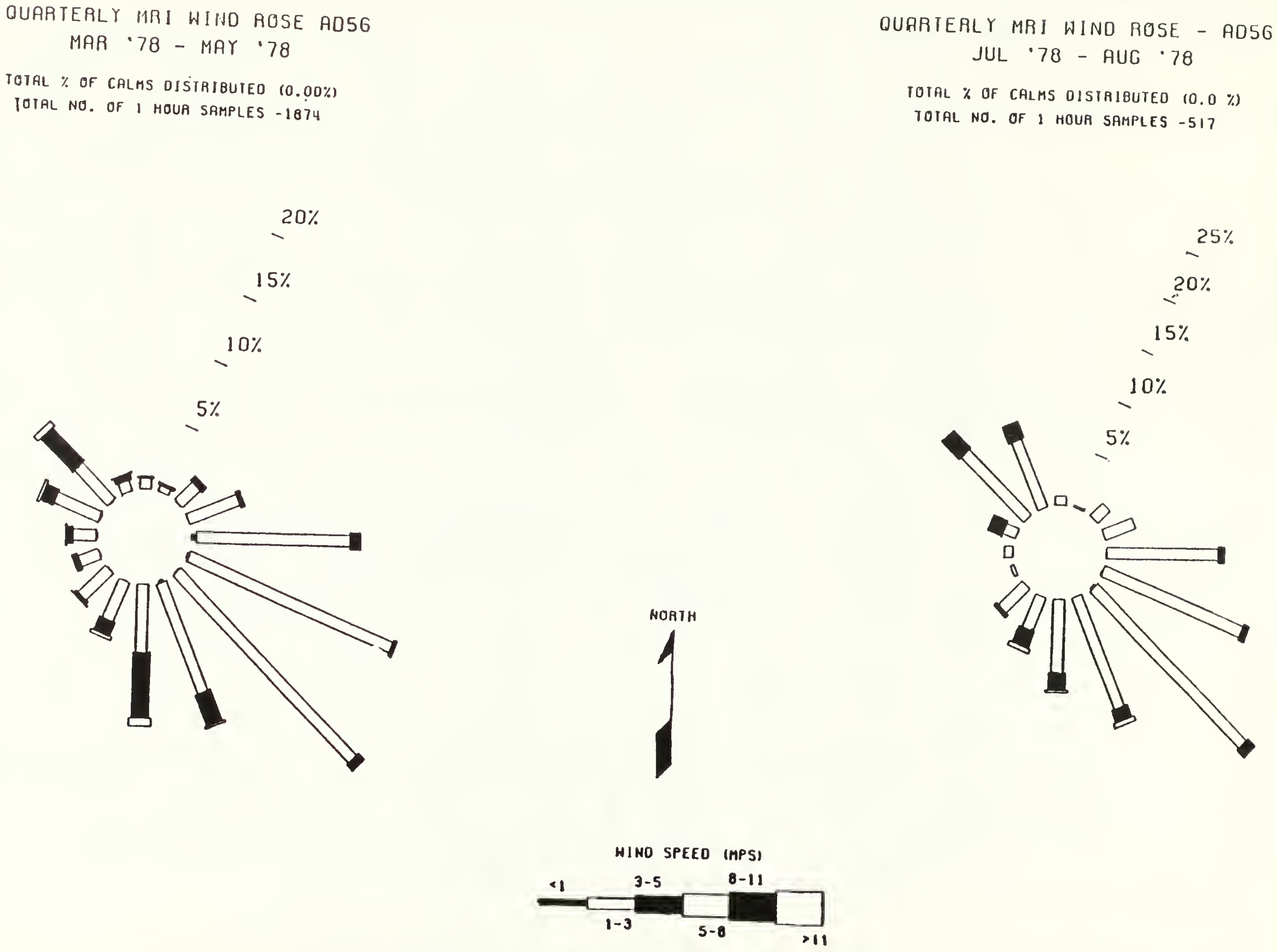


QUARTERLY MRI WIND ROSE AD42
MAR '78 - MAY '78
TOTAL % OF CALMS DISTRIBUTED (0.00%)
TOTAL NO. OF 1 HOUR SAMPLES -582

QUARTERLY MRI WIND ROSE AD42
JUN '78 - AUG '78
TOTAL % OF CALMS DISTRIBUTED (0.00%)
TOTAL NO. OF 1 HOUR SAMPLES -2198

Figure A6.3.2A-8

Station AD56 Quarterly MRI Wind Roses - 10M Level (1978)



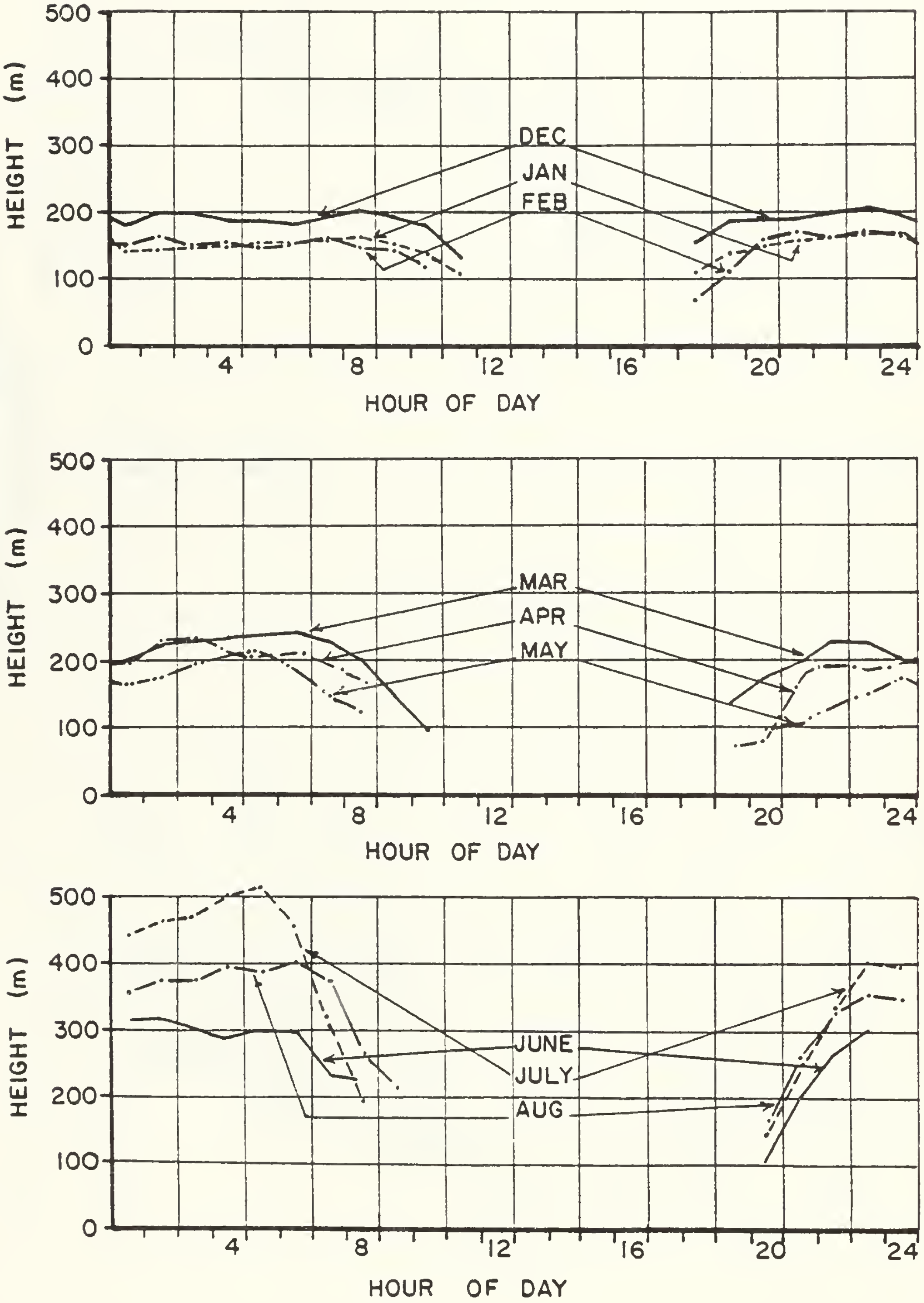
QUARTERLY MRI WIND ROSE AD56
MAR '78 - MAY '78

TOTAL % OF CALMS DISTRIBUTED (0.00%)
TOTAL NO. OF 1 HOUR SAMPLES -1874

QUARTERLY MRI WIND RØSE - AD56
JUL '78 - AUG '78

TOTAL % OF CALMS DISTRIBUTED (0.0 %)
TOTAL NO. OF 1 HOUR SAMPLES -517

FIGURE A6.3.2A-9 C-b AVERAGE HOURLY
INVERSION HEIGHT - BY QUARTER FOR 1978
STATION AB20



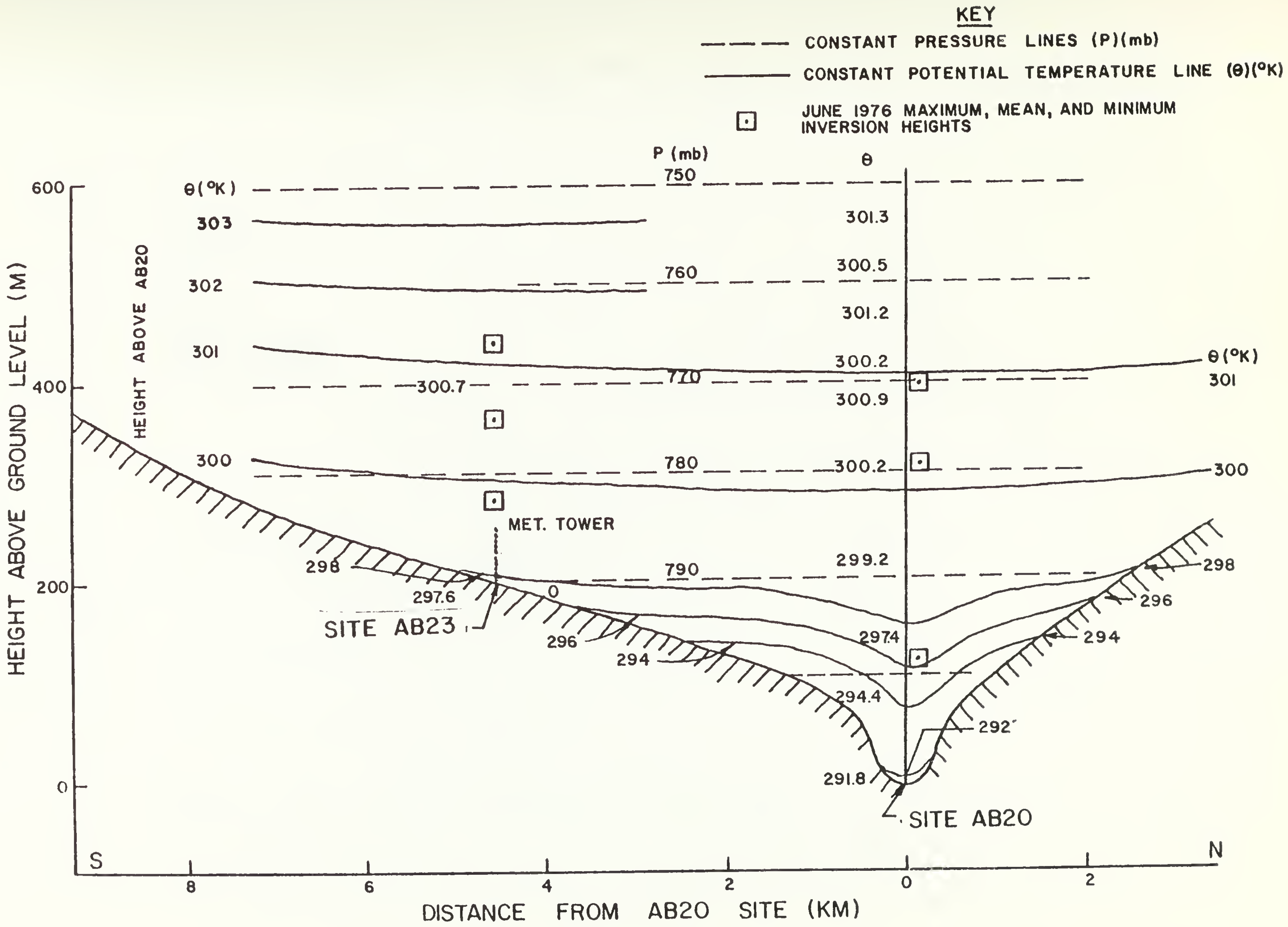


FIGURE A6.3.2A-10 JUNE 1976 INVERSION HEIGHTS PLOTTED WITH CONSTANT POTENTIAL TEMPERATURE SURFACES THROUGH STATIONS AB20 AND AB23 ON 24 JUNE 1976, 0400-0600 MST.

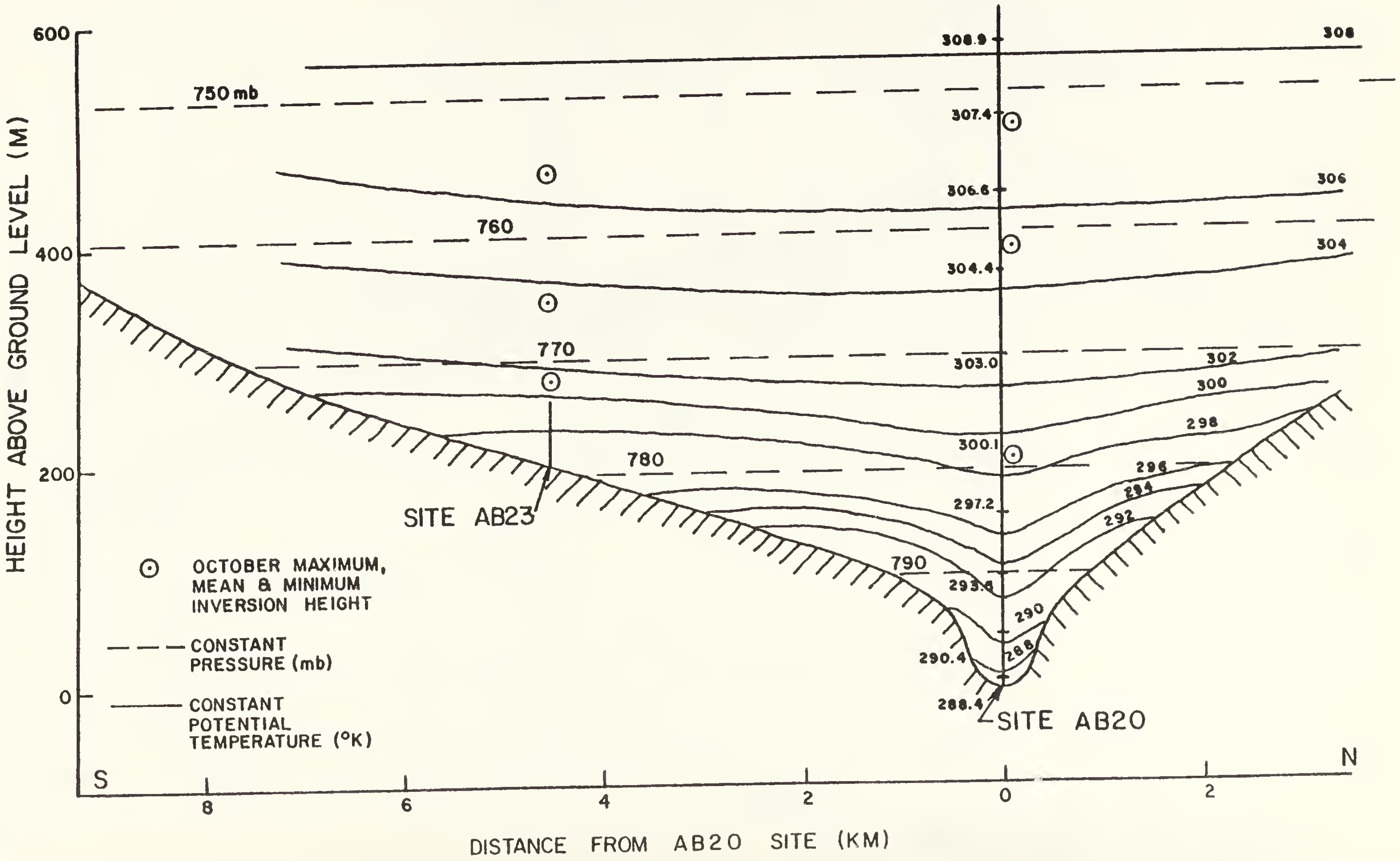


FIGURE A6.3.2A-11 OCTOBER 1976 INVERSION HEIGHTS PLOTTED WITH CONSTANT POTENTIAL TEMPERATURE SURFACES THE MORNING OF SEPTEMBER 14, 1978

FIGURE A6.3.2A-12 PIBAL ALTITUDE-TEMPERATURE

FOR SINGLE AND DOUBLE THEODOLITE OBSERVATIONS (EARLY MORNING)

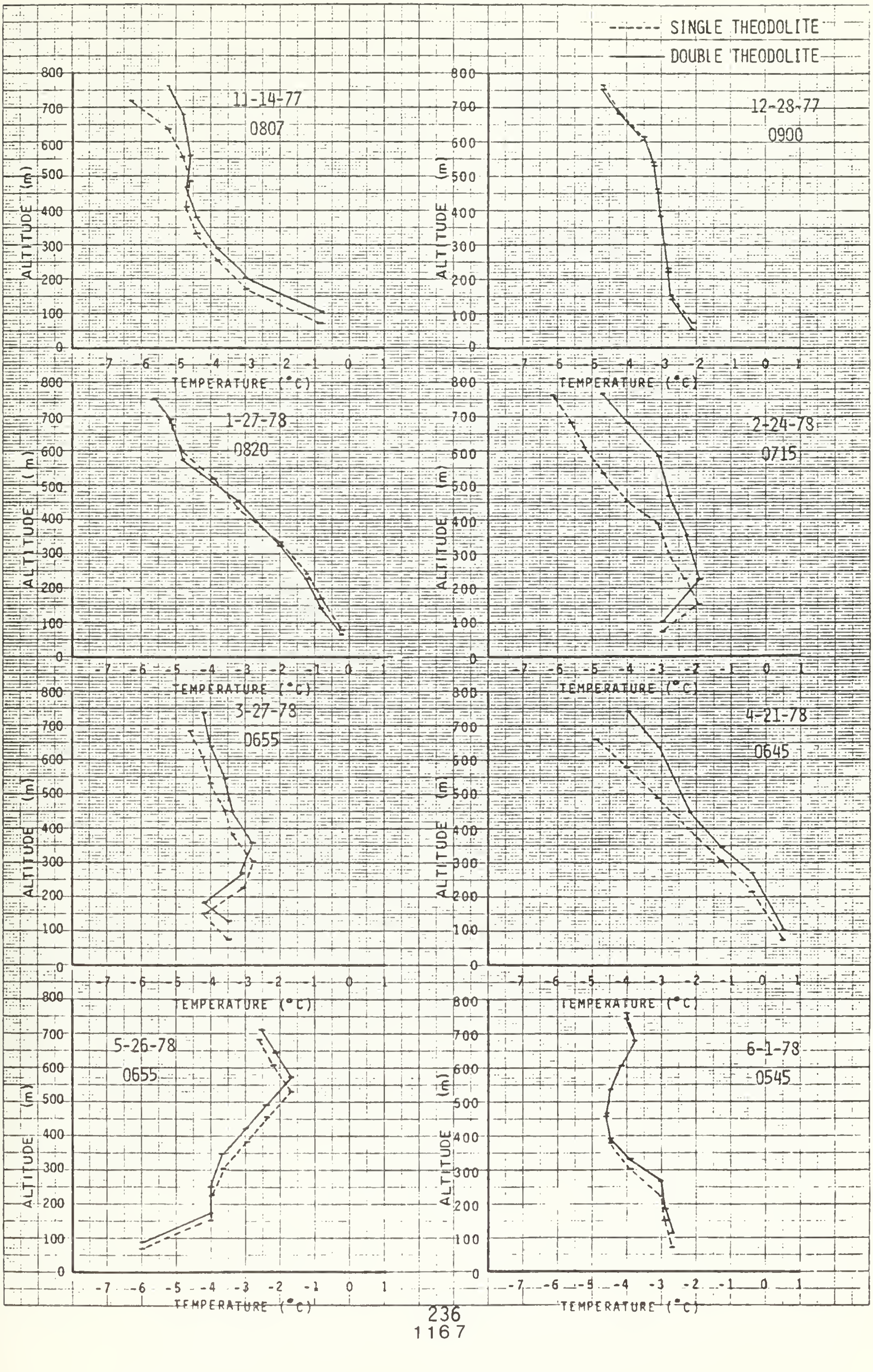
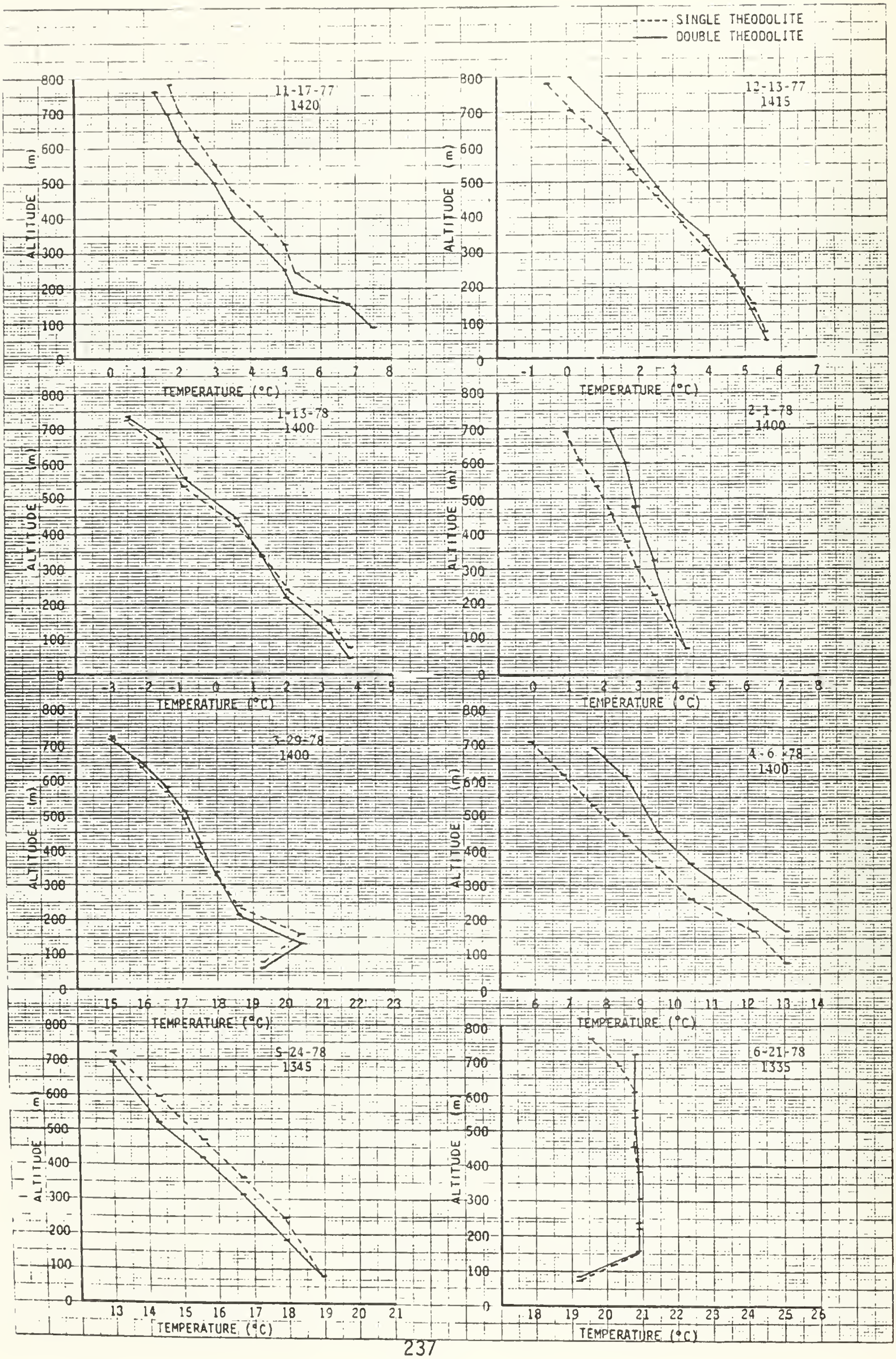


FIGURE A6.3.2A-13 PIBAL ALTITUDE - TEMPERATURE PROFILE FOR SINGLE AND DOUBLE THEODOLITE OBSERVATIONS (AFTERNOON)



APPENDIX A6.3.2B

Tracer Test Results

List of Figures Appearing in Appendix A6.3.2B

APPENDIX A6.3.2B

TRACER TEST RESULTS

To understand the distribution of tracer gas concentrations, one has to first understand the factors affecting such a distribution - namely, the meteorological conditions that existed during and immediately preceding the release of tracer gas.

Synoptic Weather Situation

After a frontal passage on September 11, a closed upper-level low formed north of Tract C-b. By the morning of September 14, a general northeast-southwest trough situation had developed from Manitoba to Nevada (See Figure A6.3.2B-1). Two distinct low pressure centers were centered in these areas with Colorado in between. Pressure gradients became weak over the tract.

After sunrise on the 14th, an anomalous blocking pattern with a warm high over Western Canada formed. By the morning of the 15th (Figure A6.3.2B-2) a fast west-east jet stream had set up along the U.S.-Canadian border. At the surface a rapidly moving, weak, dry front passed mainly south of the tract during the afternoon and early evening of the 14th. Clouds from this system cleared away shortly after midnight but the pressure maintained its weak pattern. By the afternoon of the 15th, clouds and a strong southwest flow preceding another weather front were becoming established over the tract area.

The weak pressure gradients and the lack of clouds allowed the formation of strong drainage, particularly along Piceance Creek, on the morning of September 14. Although clouds formed during the afternoon of September 14, they cleared away shortly after midnight, allowing radiative cooling of the ground to take place. The drainage that developed on the morning of September 15, however, was much weaker than that of the 14th.

Meteorological Conditions on C-b Tract, 14 September 1978

The atmospheric structure over Piceance Creek as well as over the entire tract is best illustrated by soundings taken by tethersonde near Piceance Creek. Figure A6.3.2B-3 shows three soundings of temperature taken on September 14.

As a result of strong radiative cooling, a very deep surface-based inversion appeared in the pre-dawn hours. This inversion was quite strong close to the surface but gradually weakened until about 500 m AGL, when it became isothermal. This situation was observed in soundings through 0700 MDT. Beginning at about 0800 MDT, the inversion lost more of its strength and the base of the isothermal layer lowered to about 350 m AGL. The destruction of the surface-based inversion began at about 0900 MDT and the top of the isothermal layer was detected at about 450 m AGL. This isothermal layer was topped by a neutral lapse layer. Further destruction of the surface-based inversion and lowering of the base of the neutral lapse layer continued until about 1100 MDT, when the inversion totally disappeared and was replaced by a neutral lapse condition. Similar conclusions could be derived from data collected by the acoustic radar at Site AB20.

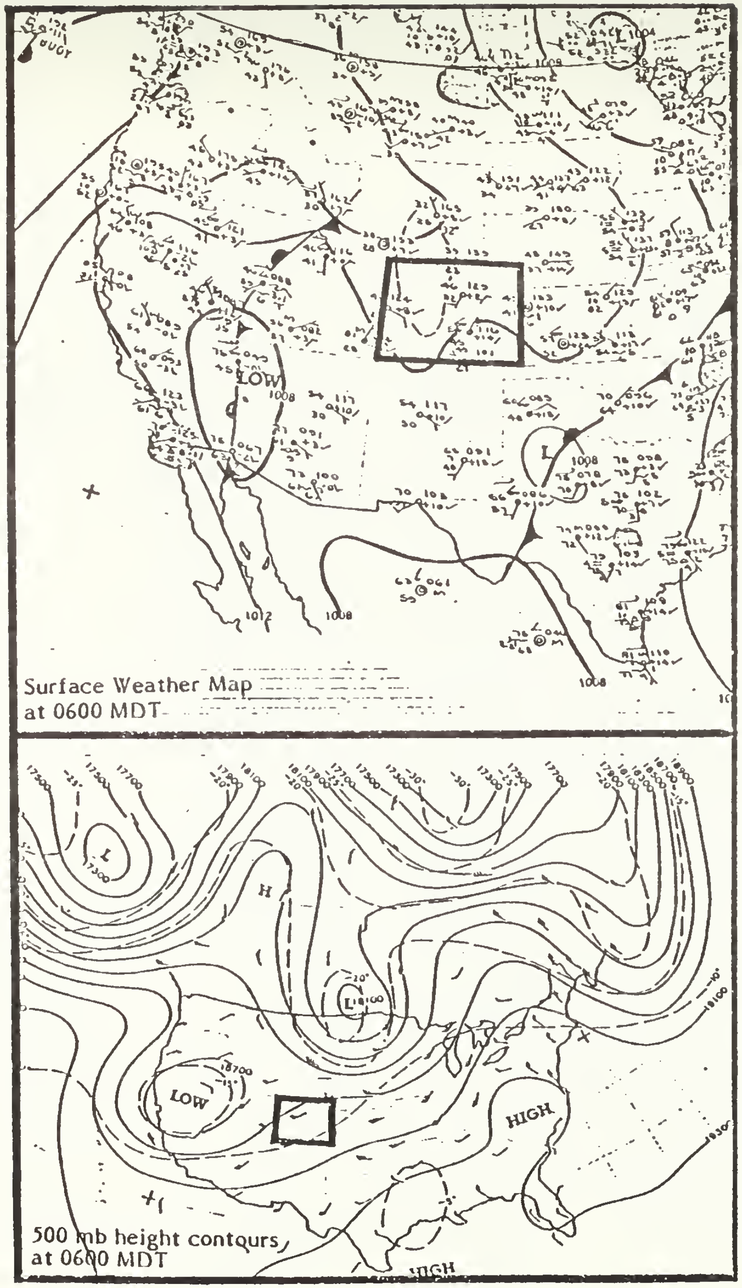


Fig. A6.3.2B-1 Synoptic weather situation on 14 September 1978.

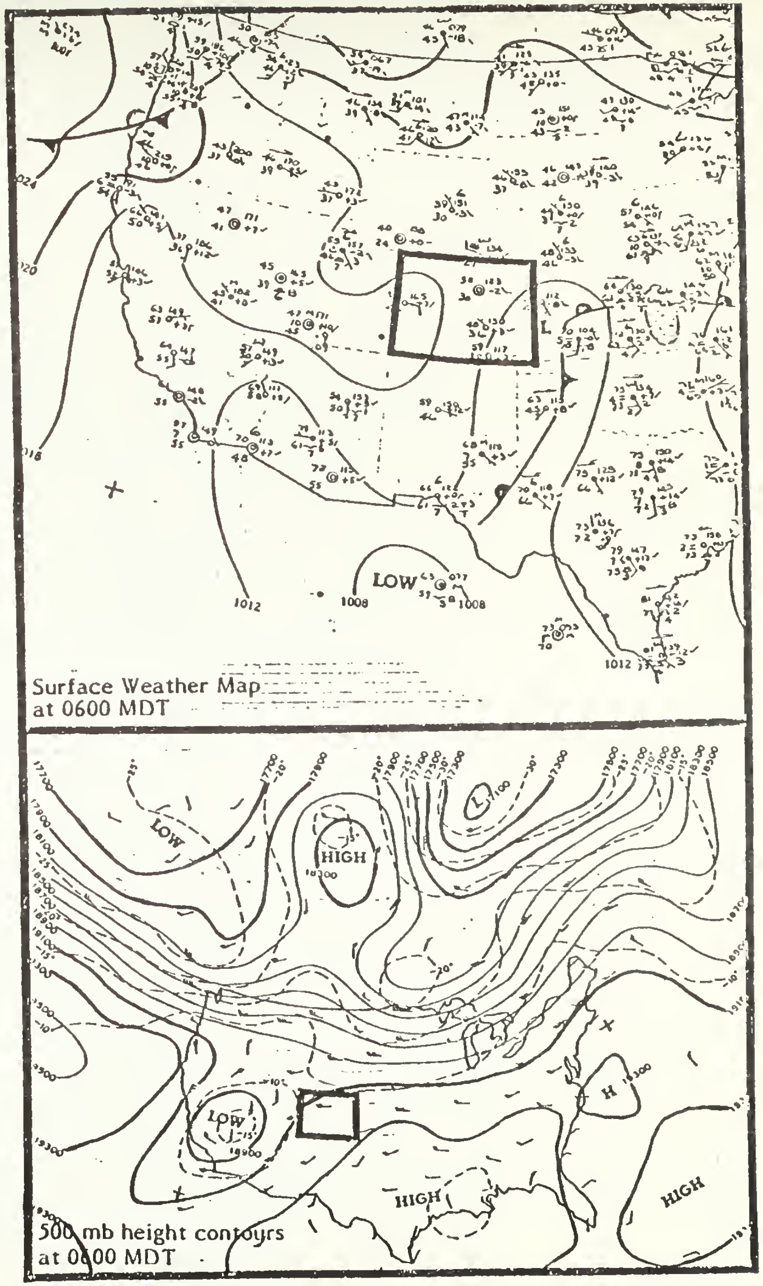


Fig. A6.3.2B-2 Synoptic weather situation on 15 September 1978.

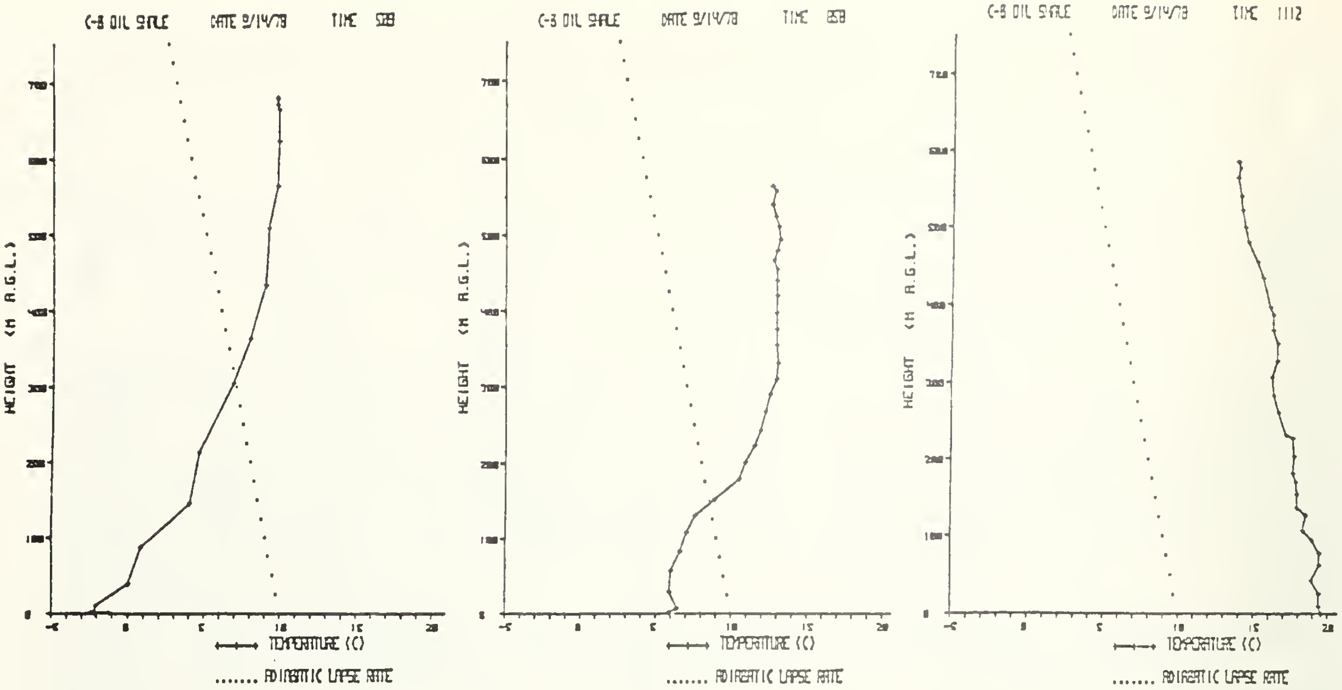


Figure A6.3.2B-3 Temperature soundings taken on 14 September 1978.

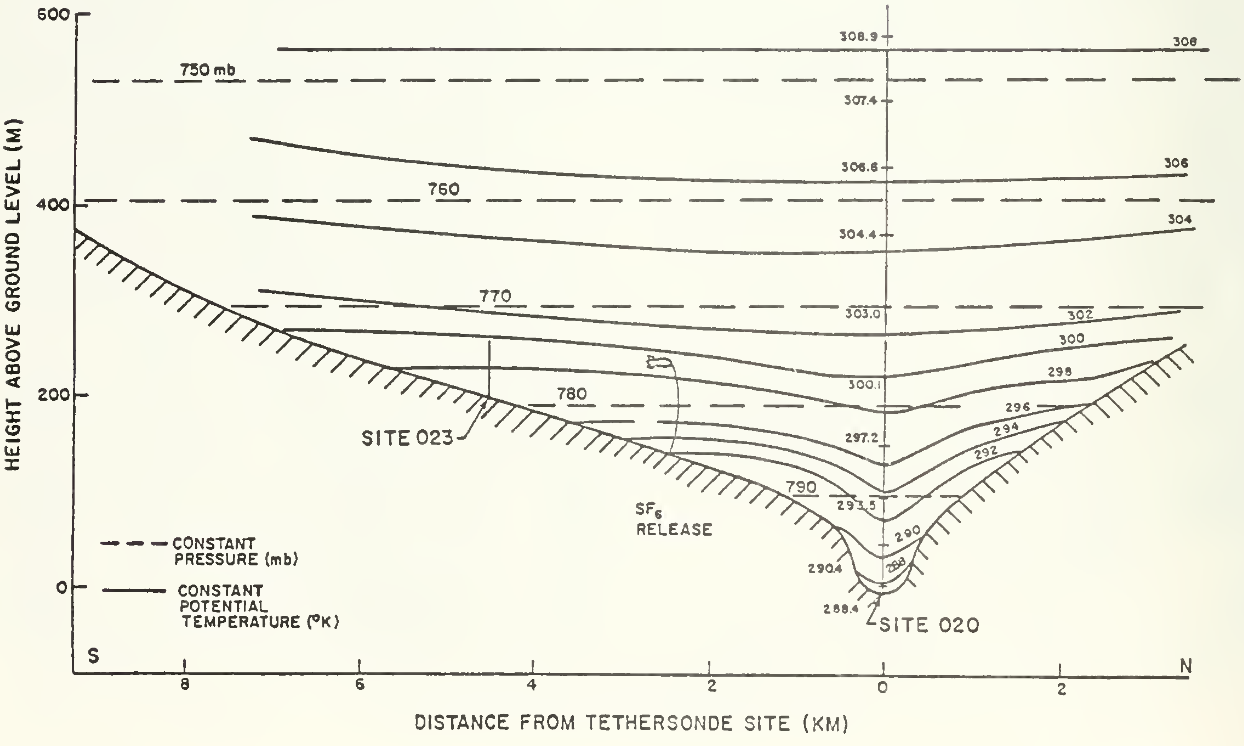


Figure A6.3.2B-4 Constant potential temperature surfaces constructed from sounding taken on the morning of 14 September 1978.

This atmospheric structure would, of course, apply only along the Piceance Creek. However, one can infer that a surface-based inversion did exist over the entire tract, even on the ridges and above the release site. This inference is supported by the delta-temperature data collected at Site AB23 as well as by tethersonde profiles taken over the tract at various locations in 1976 (C-b Shale Oil Venture, 1976) Figure A6.3.2B-4 shows what the constant potential temperature surfaces should look like over the tract.

The soundings at Site 048 also provided valuable information concerning the wind flow above the Piceance Creek. Strong drainage was evident, with the maximum speed appearing shortly after 0600 MDT at about 150 m AGL. The synoptic flow pattern was not observed below about 600 m AGL in the early morning hours. As the morning advanced, the heat gained by the surface from solar radiation exceeded that lost by terrestrial radiation and the soil temperature rose, warming the air just above. This created pressure differences resulting in an upslope flow. The evidence of this upslope flow showed up at about 0900 MDT. At this time there were still remnants of the nighttime drainage on top of this newly developed upslope flow. The strongest shear appeared at around 200 m AGL. It was not until the end of the experiment, around 1100 MDT, that the drainage flow system was totally destroyed. Even at 1100 MDT, there was still a surface layer of upslope flow to about 150 m, above which existed the synoptic flow. This wind flow picture is illustrated in Figure A6.3.2B-5. It is interesting to note that at about 300 m AGL, the wind speed was virtually zero at 0600-0700 MDT, the first hour of the sampling period.

The wind flow over the rest of the tract (other than over Piceance Creek) followed a similar pattern. Strong drainage prevailed between 0400-0600 MDT. Figure A6.3.2B-6 shows streamlines of the drainage situation while Figure A6.3.2B-7 shows what the drainage looks like in a cross-section between Sites AB23 and AB20.

During the first hour of sampling, the overall pattern was still of the drainage type although almost calm conditions were detected at various locations over the tract. At the release site, the kytoon was observed to head towards the west, then rotated clockwise during the hour to finally end up pointing towards the south-southeast direction.

The second hour of sampling saw the head of the kytoon meandering between south-southeast to east. In other words, the wind at the level of release was from the south-southeast to east. Over other parts of the tract, the wind was light and often variable, with the predominant direction from the eastern sector. This is probably due to the fact that the tract is located west of the Continental Divide and in the macroscale, there would be a drainage that flows generally from east to west over the tract.

Between 0800-0900 MDT, the wind at the point of release, as indicated by the heading of the kytoon, was from the southeast to east. Meteorological data from other wind stations indicated that the wind was still light and variable, without a definitely organized flow system.

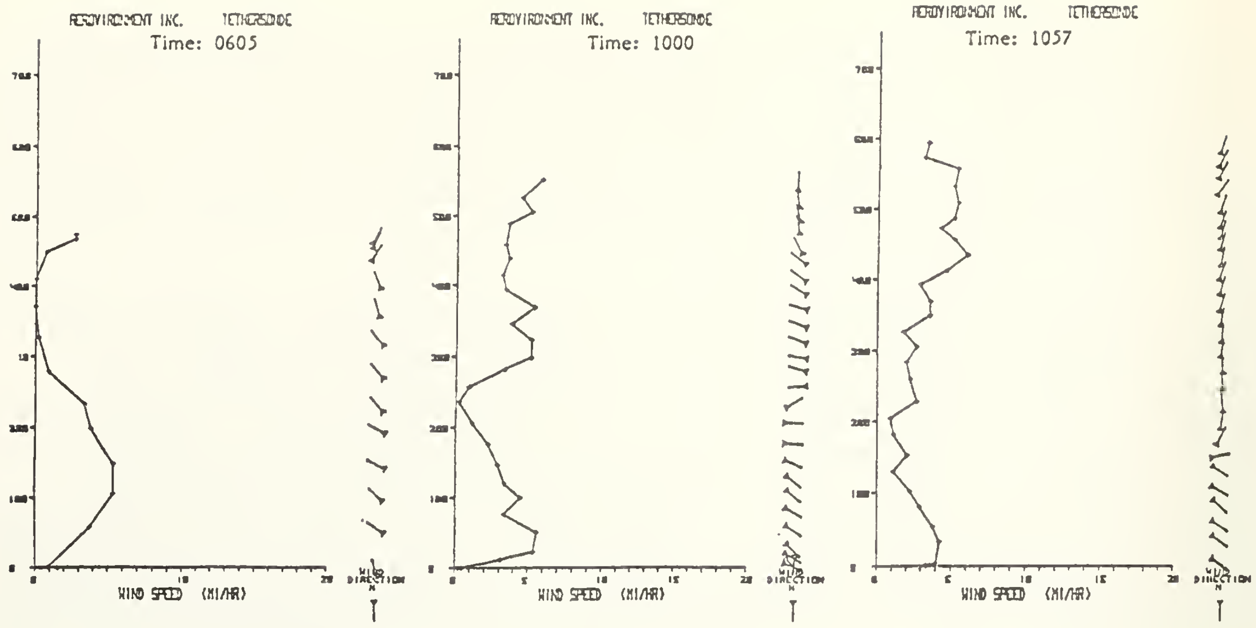


Figure A6.3.2B-5 Wind soundings taken on 14 September 1978.

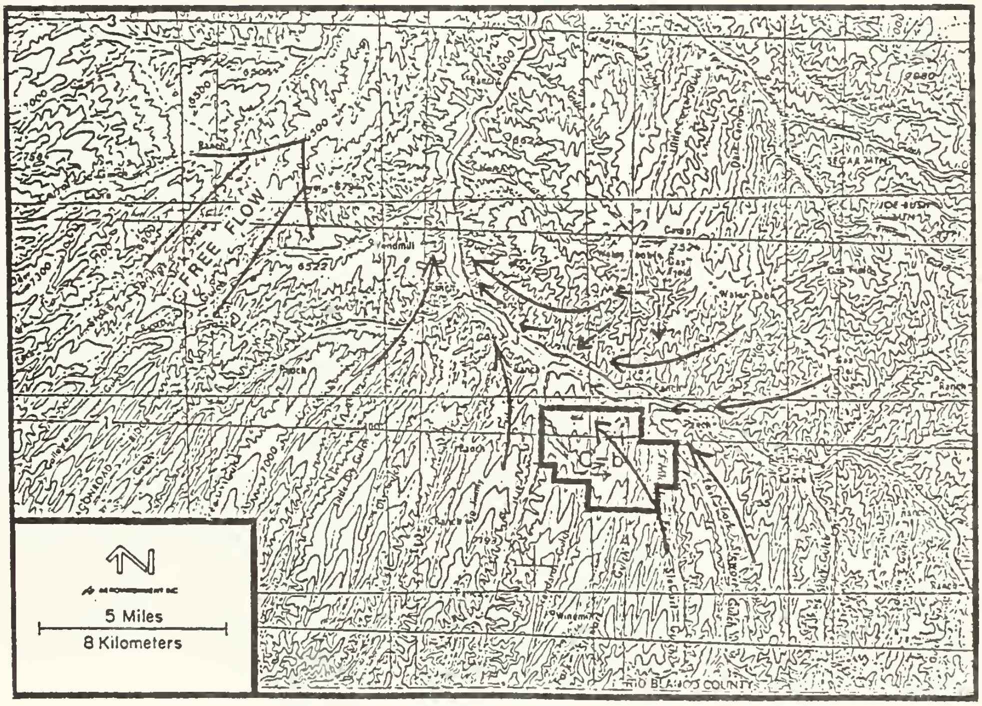


Figure A6.3.2B-6 Streamlines of drainage situation over Tract C-b.

During the last two hours of the sampling period, the heading of the kytoon indicated that the wind at the point of release was from the north to east quadrant. Data collected also indicated that the wind was generally from the north in areas south of the Piceance Creek and from areas north of the Piceance Creek. This phenomenon is generalized in Figure A6.3.2B-8 and Figure A6.3.2B-9.

The synoptic flow (winds from the south) was never established at the surface during the sampling period. It appeared around noon. Figure A6.3.2B-10 shows a picture of the synoptic pattern in the afternoon.

Data collected at Site AB23 showed that turbulence was weak throughout the period of sampling, especially between 0600-0800 MDT.

In summary, during the first three hours of sampling drainage was evident along Piceance Creek and the gulches leading to Piceance Creek. Over the ridges and higher ground, the surface flow was disorganized and weak. In the last two hours of sampling, an upslope flow was discernible all over the tract. Turbulence was weak, especially between 0600-0800 MDT.

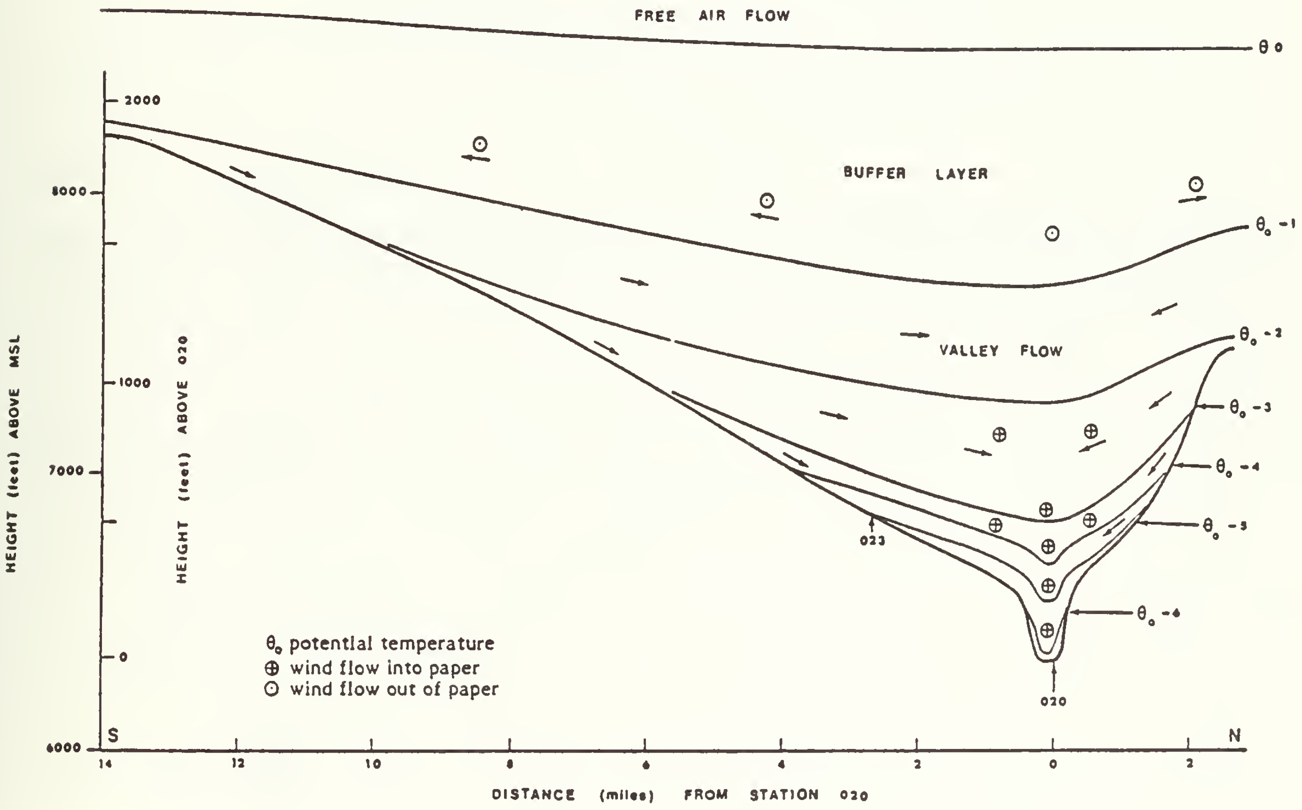


Figure A6.3.2B-7 A cross-sectional view of the drainage flow.

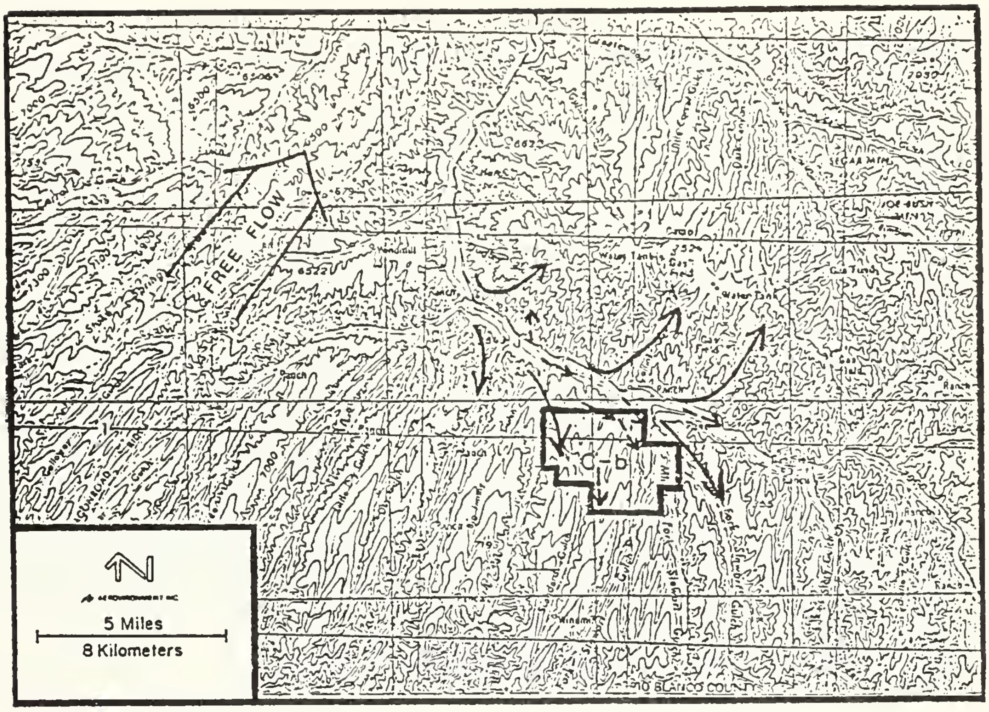


Figure A6.3.2B-8 Streamlines of upslope flow over Tract C-b.

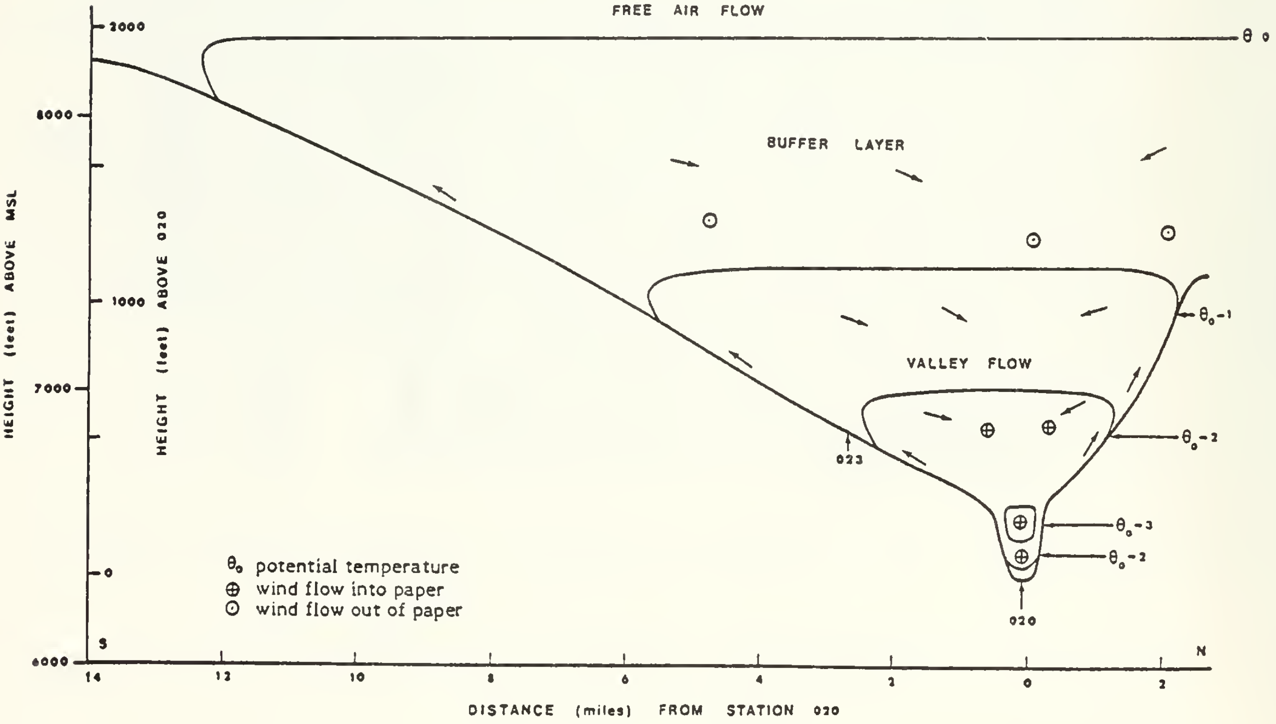


Figure A6.3.2B-9 A cross-sectional view of the upslope flow.

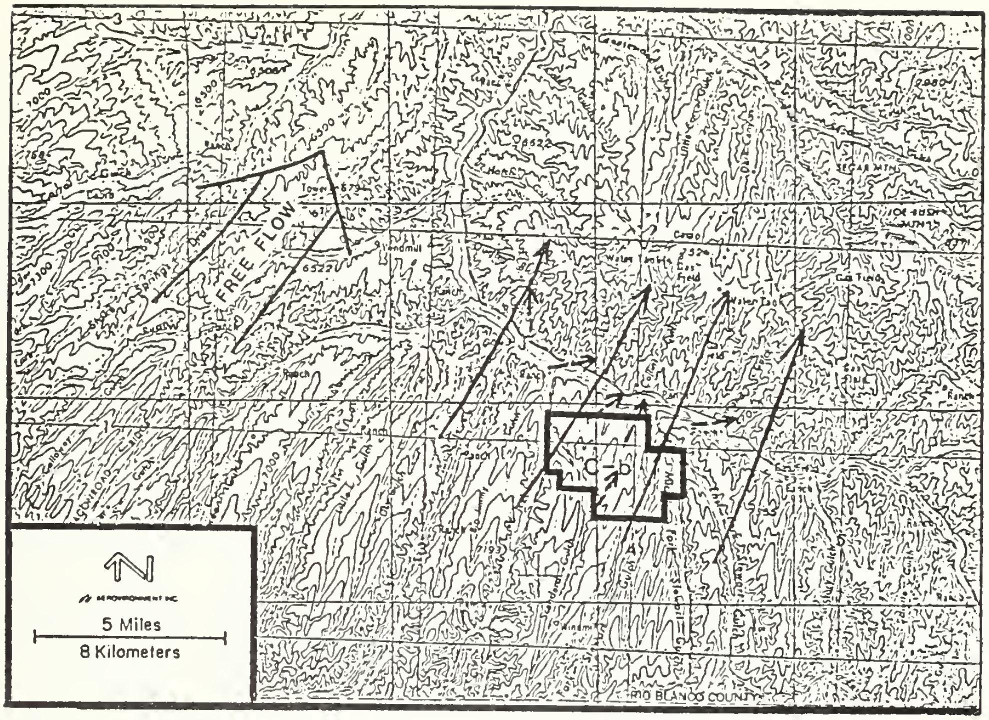


Figure A6.3.2B-10 Streamlines of synoptic flow over Tract C-b.

Tracer Gas Release Data

The release rate was kept fairly constant during the experiment, at about 3.21 gm/sec (28.8 lb/hr) in the first day and 3.14 gm/sec (28.0 lb/hr) in the second day. The height of release was approximately 100 m (330 ft) AGL.

Distribution of Ground Level SF_6 Concentration

The actual observed SF_6 concentrations at all sites are presented in the data report for January 15, 1978.

Table A8.2.1-1a

Deer pellet-group densities in the chained rangeland habitat, 1977-78.

Transect	Mean pellet-groups per acre ± SE	No. of 0.01 acre plots
BA 17 (CH-C-1)	235 ± 56	20
BA 18 (CH-C-2)	245 ± 52	20
BA 25 (CH-C-3)	385 ± 62	20
Combined	288 ± 33	60
BA 21 (CH-T-1)	495 ± 67	20
BA 20 (CH-T-2)	535 ± 72	20
BA 23 (CH-T-3)	274 ± 38	19
Combined	437 ± 38	59

Table A8.2.1-1b

Deer pellet-group densities in the pinyon-juniper habitat, 1977-78.

Transect	Mean pellet-groups per acre ± SE	No. of 0.01 acre plots
BA 19 (PJ-C-1)	360 ± 56	20
BA 26 (PJ-C-2)	110 ± 34	20
BA 27 (PJ-C-3)	245 ± 53	20
Combined	238 ± 31	60
BA 16 (PJ-T-1)	310 ± 77	20
BA 22 (PJ-T-2)	195 ± 38	19
BA 24 (PJ-T-3)	90 ± 16	20
Combined	198 ± 31	59

Table A8.2.1-1c

Deer pellet-group densities in the chained rangeland habitat on Big Jimmy ridge, 1977-78.

Transect	Mean pellet-groups per acre ± SE	No. of 0.01 acre plots
BA 01	355 ± 60	20
BA 02	420 ± 73	20
BA 03	430 ± 66	20
BA 04	360 ± 41	20
BA 05	580 ± 88	20
BA 06	205 ± 44	20
BA 07	210 ± 69	20
BA 08	415 ± 61	20
BA 09	610 ± 90	20
Combined	398 ± 24	180

Table A8.2.1-1d

Deer pellet-group densities in the pinyon-juniper habitat north of Piceance Creek, 1977-78.

Transect	Mean pellet-groups per acre ± SE	No. of 0.01 acre plots
BA 10	95 ± 26	20
BA 11	90 ± 22	20
BA 12	130 ± 31	20
Combined	105 ± 15	60
BA 13	345 ± 69	20
BA 14	440 ± 47	20
BA 15	285 ± 48	20
Combined	357 ± 33	60

Table A8.2.2-1

Mule deer road counts conducted from Fall 1977 to Spring 1978.

Mile	Location	SEP		OCT					NOV				Fall Totals
		22	29	6	13	20	24	27	3	10	17	24	
41	White River												
40													
39													
38													
37													
36													
35													
34	Little Hills											4	4
33													
32								3					3
31								40	15	13		19	87
30								12					12
29													
28						3	7						10
27							5			8	7		20
26							7	9					16
25							5	42	24				71
24	Rock School							4		21			25
23												5	5
22						4	18	51	23		24	10	130
21	Hunter Creek						16	18		83	10	6	133
20	PL Gate				14	15	126	150	7	72	57	7	448
19	AQ 020					8	106	205	96		61		476
18	Sorghum, Cottonwood						115	122	41	60	45	9	392
17	Stewart Gulch Rd.						30	101	236	138	8	5	518
16	AQ Trailer 021						25	28	25	21	8	17	124
15							6	25	5		6		42
14								3	15				18
13								6					6
12	Sprague Gulch								3	2			5
11													
10									8				8
9													
8													
7													
6													
5													
4													
3								6					6
2							1	7					8
1							3	3					6
0	Rio Blanco							2					2
TOTAL		0	0	0	14	30	480	837	498	418	226	82	

Table A8.2.2-1 (Continued)

Mile	Location	DEC 3	DEC 8	DEC 15	DEC 21	DEC 29	JAN 5	JAN 12	JAN 19	JAN 25	Winter Totals
41	White River										
40											
39										5	5
38											
37											
36											
35											
34	Little Hills				1						1
33			1			2					3
32			7	3							10
31		13	15	5		8				5	46
30			10								10
29											
28					5	3					8
27			6	15							21
26					3						3
25			4		6						10
24	Rock School				5	5					10
23							1			1	2
22		9	68	34	4	18	12	1		8	154
21	Hunter Creek	19.	16							4	39
20	PL Gate		2	23			2				27
19	AQ 020		4								4
18	Sorghum, Cottonwood										
17	Stewart Gulch Rd.										
16	AQ Trailer 021						1				1
15						2					2
14											
13			5								5
12	Sprague Gulch										
11				5							5
10							3				3
9							2				2
8											
7							6				6
6											
5										1	1
4											
3											
2											
1											
0	Rio Blanco						2				2
TOTAL		41	138	85	24	38	29	1	0	24	

Table A8.2.2-1 (Continued)

		FEB				MAR					Spring
Mile	Location	2	9	16	23	2	9	16	23	30	Totals
41	White River										
40							23		48		71
39					17	7		13	6		43
38					3		9	10	11		33
37				3	17		1	21	24		66
36					11				28		39
35			2	15	7				1	1	26
34	Little Hills			3	2						5
33					13			5			18
32					3	6	4	2		5	20
31					13	2	7	59	41	14	136
30				21	20	2	18	9	38		108
29					26	10		55	11	15	117
28			5	8	18	28	18			25	102
27					23			21	24	5	73
26					2		7	10	20	40	79
25				13	40		12	27	113	88	293
24	Rock School	6		11	53	2	17	40	39	58	226
23				3	11		8	13	19	17	71
22		2	13	9	23		37	9	81	61	235
21	Hunter Creek			8	74		61	62	12		217
20	PL Gate			31	13		24	45	25	75	213
19	AQ 020		3	18			13	22	49	47	152
18	Sorghum, Cottonwood		3	6			3	43	8	57	120
17	Stewart Gulch Rd.		4		20	3	10	15		18	70
16	AQ Trailer 021				5			5	4	12	26
15				10	4			33	3	2	52
14			3	4	8			20		10	45
13			21	18	13	8	1	21		21	103
12	Sprague Gulch		26	5	41	1	11	67		20	171
11		1	8	36	22	1	4	79		12	163
10			14	51	24			23		6	118
9		5	3	9	7	7	8	50	14	27	130
8		21	9	13	31	11	54	37	15		191
7			4	4	19	3	21	42	3	30	126
6			16		16		9	50		3	94
5						3		22			25
4					9		23	18	1		51
3		2		25	6			21			54
2			1	23	28	3	18	39			112
1				14	8			26			48
0	Rio Blanco										
TOTAL		37	135	361	650	97	421	1034	638	669	

Table A8.5.1-1

BIRD SPECIES OBSERVED ON TRACT C-b DURING SPRING 1978 CENSUS

ORDER Family Species	Common Name	Observed		
		Pinyon-juniper	Chained pinyon-juniper	Fly over
FALCONIFORMES				
ACCIPITRIDAE				
Buteo jamaicensis	red-tailed hawk			X
COLUMBIFORMES				
COLUMBIDAE				
Zenaida macroura	mourning dove	X	X	
APODIFORMES				
APODIDAE				
Aeronautes saxatalis	white-throated swift			X
TROCHILIDAE				
Selasphorus platycercus	broad-tailed hummingbird	X	X	
PICIFORMES				
PICIDAE				
Colaptes auratus	common flicker	X	X	
Sphyrapicus thyroideus	Williamson's sapsucker	X		
Picoides villosus	hairy woodpecker	X		
PASSERIFORMES				
TYRANNIDAE				
Myiarchus cinerascens	ash-throated flycatcher	X	X	
Empidonax hammondii	Hammond's flycatcher	X		
Empidonax oberholseri	dusky flycatcher	X		

Table A8.5.1-1 (cont'd)

ORDER Family Species	Common Name	Observed		
		Pinyon-juniper	Chained pinyon-juniper	Fly over
PASSERIFORMES (cont.)				
CORVIDAE				
Gymnorhinus cyanocephalus	pinyon jay	X	X	
Corvus corax	common raven			X
PARIDAE				
Parus gambeli	mountain chickadee	X		
Parus Inornatus	plain titmouse	X		
Psaltriparus minimus	bushtit	X		
SITTIDAE				
Sitta carolinensis	white-breasted nuthatch	X		
TROGLODYTIDAE				
Troglodytes aedon	house wren	X	X	
TURDIDAE				
Myadestes townsendi	Townsend's solitaire	X		
Catharus guttata	hermit thrush	X		
Sialia currucoides	mountain bluebird	X	X	
VIREONIDAE				
Vireo solitarius	solitary vireo	X		
PARULIDAE				
Vermivora virginiae	Virginia's warbler	X		
Dendroica coronata	yellow-rumped warbler		X	
Dendroica nigrescens	black-throated gray warbler	X	X	

Table A8.5.1-1 (cont'd)

ORDER Family Species	Common Name	Observed		
		Pinyon-juniper	Chained pinyon-juniper	Fly over
FRINGILLIDAE				
Pheucticus melanocephalus	black-headed grosbeak	X		
Carpodacus cassinii	Cassin's finch	X		
Carpodacus mexicanus	house finch		X	
Cardeulis pinus	pine siskin	X		
Pipilo chlorura	green-tailed towhee	X	X	
Pipilo erythropthalmus	rufous-sided towhee	X		
Passerculus sandwichensis	savannah sparrow		X	
Pooecetes gramineus	vesper sparrow		X	
Junco caniceps	gray-headed junco	X		
Spizella passerina	chipping sparrow	X	X	
Spizella breweri	Brewer's sparrow	X	X	

TABLE A8.5.1-2a

AVIFAUNA ESTIMATES AT TRACT C-b FOR SPRING SAMPLE PERIOD, 1978

TRANSECT 1, CHAINED PINYON-JUNIPER RANGELAND (CONTROL).

Species	# Obs	Coeff det	Basal adj	Density /ha	%Relative abundance (1)
Mourning dove	1	1.00	*	0.02	0.9
Broad-tailed hummingbird	1	0.28	*	0.09	4.1
Ash-throated flycatcher	1	0.63	*	0.04	1.8
House wren	2	0.65	*	0.08	3.6
Mountain bluebird	8	*	*	0.20	9.1
Black-throated gray warbler	1	1.00	*	0.03	1.4
House finch	1	0.62	*	0.04	1.8
Green-tailed towhee	8	0.57	*	0.36	16.4
Savannah sparrow	5	0.63	*	0.20	9.1
Chipping sparrow	1	0.63	*	0.04	1.8
Brewer's sparrow	21	0.49	*	1.10	50.0
	Total			2.20	

(1) $\frac{\text{Species density/ha}}{2.20} \times 100\%$

TABLE A8.5.1-2b

AVIFAUNA ESTIMATES AT TRACT C-b FOR SPRING SAMPLE PERIOD, 1978

TRANSECT 2, PINYON-JUNIPER WOODLAND (DISTURBED)

Species	# Obs	Coeff det	Basal adj	Density /ha	% Relative abundance (1)
Broad-tailed hummingbird	1	0.73	*	0.04	2.1
Common flicker	1	0.90	*	0.03	1.5
Ash-throated flycatcher	2	0.50	*	0.10	5.2
Pinyon jay	2	1.00	*	0.05	2.6
Mountain chickadee	5	0.56	*	0.23	11.8
Plain titmouse	1	0.31	*	0.08	4.1
Bushtit	3	0.22	*	0.35	18.0
White-breasted nuthatch	1	0.59	*	0.04	2.1
Mountain bluebird	3	0.42	*	0.18	9.2
Solitary vireo	2	0.59	*	0.09	4.6
Virginia's warbler	7	0.75	*	0.24	12.4
Black-throated gray warbler	8	0.60	*	0.34	17.5
Black-headed grosbeak	1	0.75	*	0.03	1.5
Gray-headed junco	1	0.43	*	0.06	3.1.
Brewer's sparrow	2	0.62	*	0.08	4.1
		Total		1.94	

(1) $\frac{\text{Species density/ha}}{2.20}$ X 100%

TABLE A8.5.1-2c

AVIFAUNA ESTIMATES AT TRACT C-b FOR SPRING SAMPLE PERIOD, 1978

TRANSECT 3, CHAINED PINYON-JUNIPER RANGELAND (DISTURBED)

Species	# Obs	Coeff det	Basal adj	Density /ha	% Relative abundance (1)
Broad-tailed hummingbird	1	0.28	*	0.09	2.3
Common flicker	2	1.00	*	0.05	1.3
Ash-throated flycatcher	3	0.63	*	0.12	3.1
Pinyon jay	4	0.25	*	0.41	10.7
House wren	2	0.65	*	0.08	2.1
Mountain bluebird	10	*	*	0.26	6.8
Yellow-rumped warbler	2	0.19	*	0.27	7.0
Green-tailed towhee	24	0.57	*	1.08	28.2
Vesper sparrow	3	0.57	*	0.10	2.6
Chipping sparrow	3	0.63	*	0.12	3.1
Brewer's sparrow	24	0.49	*	1.25	32.6
		Total		3.83	

(1) $\frac{\text{Species density/ha}}{2.20}$ X 100%

TABLE A8.5.1-2d

AVIFAUNA ESTIMATES AT TRACT C-b FOR SPRING SAMPLE PERIOD, 1978

TRANSECT 4, PINYON-JUNIPER WOODLAND (CONTROL)

Species	# Obs	Coeff det	Basal adj	Density /ha	% Relative abundance (1)
Mourning dove	5	0.74	*	0.17	4.2
Williamson's sapsucker	1	0.38	*	0.07	1.7
Hammond's flycatcher	1	0.25	*	0.10	2.5
Dusky flycatcher	7	0.44	*	0.41	10.2
Mountain chickadee	5	0.56	*	0.23	5.7
Bushtit	2	0.22	*	0.23	5.7
House wren	5	0.45	*	0.28	6.9
Hermit thrush	4	0.66	*	0.16	4.0
Mountain bluebird	10	0.42	*	0.61	15.1
Solitary vireo	7	0.59	*	0.30	7.4
Black-throated gray warbler	16	0.60	*	0.68	16.9
Black-headed grosbeak	2	0.75	*	0.07	1.7
Cassin's finch	1	0.50	*	0.05	1.2
Pine siskin	1	0.43	*	0.06	1.5
Green-tailed towhee	2	0.54	*	0.10	2.5
Rufous-sided towhee	1	0.54	*	0.05	1.2
Chipping sparrow	5	0.34	*	0.38	9.4
Brewer's sparrow	2	0.62	*	0.08	2.0
		Total		4.03	

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(1) $\frac{\text{Species density/ha}}{2.20} \times 100\%$

Table A8.6.2-1

Abundance (units/cm^2), percent relative abundance (%RA), and species diversity of periphyton from artificial substrates on Piceance Creek, Colorado at Stewart and Hunter Stations, May 18, 1978

Taxon	Stewart					Hunter				
	Rep 4	Rep 5	Rep 6	Mean	%RA	Rep 4	Rep 5	Rep 6	Mean	%RA
DIVISION BACILLARIOPHYTA (Diatoms)										
Achnanthes lanceolata var. dubia	6	16	18	13.3	2.0	6	4	6	5.3	1.1
A. minutissima	10	16	16	14.0	2.1	16	38	28	27.3	5.8
Amphora sp.							4	2	2.0	0.4
Cocconeis placentula	P	6	2	2.7	0.4	6	2		2.7	0.6
Cymbella minuta	2	4	2	2.7	0.4					
C. tumida						4	2	2	2.7	0.6
Denticula sp.								2	0.7	0.1
Fragilaria crotonensis			2	0.7	0.1					
F. vaucheriae			P	P						
Gomphonema gracile								2	0.7	0.1
G. olivaceum	2	6	6	4.7	0.7	20	4		8.0	1.7
G. parvulum	12		16	9.3	1.4	42	28		23.3	3.0
G. subclavatum var. commutatum						2	4	4	3.3	0.7
G. spp.	10	6		5.3	0.8		12	2	4.7	1.0
Gyrosigma sp.		2	6	2.7	0.4	16			5.3	1.1
Hantzschia amphioxys	6	4	8	6.0	0.9	4		2	2.0	0.4
Melosira varians			P	P						
Meridion circulare		P	4	1.3	0.2					
Navicula accomoda	4	2		2.0	0.3					
N. capitata	2		2	1.3	0.2			4	1.3	0.3
N. cryptocephala	P		2	0.7	0.1	P	P	P	P	
N. cryptocephala var. veneta	85	89	87	87.0	13.0	12	10	12	11.3	2.4
N. cuspidata			2	0.7	0.1					
N. nr. menisculus var. upsaliensis						2	4		2.0	0.4
N. minima	4		2	2.0	0.3			8	2.7	0.6
N. mutica						P			P	

Table A8.6.2-1 (Continued)

Taxon	Stewart					Hunter				
	Rep 4	Rep 5	Rep 6	Mean	%RA	Rep 4	Rep 5	Rep 6	Mean	%RA
Navicula mutica var. *undulata*			2	0.7	0.1					
N. secreta var. *apiculata*	71	85	83	79.7	11.9	57	63	40	53.3	11.4
N. tripunctata var. *schizonemoides*	40	55	32	42.3	6.3	55	81	69	68.3	14.6
N. viridula var. *avenacea*	6	32	20	19.3	2.9	P	P	P	P	
N. spp.	47	51	55	51.0	7.6	34	16	20	23.3	5.0
Neidium sp.	2			0.7	0.1					
Nitzschia acicularis	12	16	8	12.0	1.8	12	20	24	18.7	4.0
N. apiculata	P			P				2	0.7	0.1
N. dissipata	P			P			4		1.3	0.3
N. hungarica	2	4	4	3.3	0.5					
N. palea	26	63	42	43.7	6.5	16	36	34	28.7	6.1
N. sigmoidea	2		4	2.0	0.3	P			P	
N. tryblionella var. *levidensis*		2	2	1.3	0.2					
N. spp.	142	206	199	182.3	27.2	97	145	122	121.3	26.0
Pinnularia borealis			2	0.7	0.1					
P. sp.			4	1.3	0.2					
Rhopalodia gibba var. *ventricosa*			P	P						
R. musculus	2			0.7	0.1					
Stephanodiscus hantzschii			P	P						
Surirella angustata	P	2		0.7	0.1					
S. ovalis	10			3.3	0.5		2		0.7	0.1
S. ovata	26	38	32	32.0	4.8	P	8	4	4.0	0.8
Synedra delicatissima	6			2.0	0.3					
S. fasciculata						P			P	
S. ulna			P	P						
S. sp.		2	4	2.0	0.3	2			0.7	0.1
Unidentified centrics								2	0.7	0.1

Table A8.6.2-1 (Continued)

Taxon	Stewart					Hunter				
	Rep 4	Rep 5	Rep 6	Mean	%RA	Rep 4	Rep 5	Rep 6	Mean	%RA
Unidentified pennates	43	43	16	34.0	5.1	38	36	26	33.3	7.1
Total Bacillariophyta	579	749	682	670.0	99.9	439	520	417	458.7	98.2
DIVISION CHLOROPHYTA (Green algae)										
Crucigenia quedrata						2		2	1.3	0.3
Stigeoclonium sp.						4	8	P	4.0	0.8
Unidentified coccoids						8			2.7	0.6
Total Chlorophyta						14	8	2	8.0	1.7
DIVISION CYANOPHYTA (Blue-green algae)										
Oscillatoria sp.	2			0.7	0.1					
Total Cyanophyta	2			0.7	0.1					
DIVISION CRYPTOPHYTA										
Cryptomonas ovata							2		0.7	0.1
Total Cryptophyta							2		0.7	0.1
Total Individuals	581	749	682	670.7		453	530	419	467.3	
Total Taxa	32	24	36	46		28	25	26	39	
Diversity ($\bar{d}$)	3.64	3.48	3.62	3.67		3.69	3.50	3.42	3.70	
Maximum diversity ($\bar{d}$ max)	4.75	4.52	4.95	5.28		4.46	4.52	4.58	5.09	
Equitability (%)	76.60	76.97	73.18	69.39		82.85	77.39	74.67	72.63	

P = present

Table A8.6.2-2

Abundance (units/cm^2), percent relative abundance (%RA), and species diversity ($\bar{d}$) of periphyton from artificial substrates on Piceance Creek, Colorado at Stewart and Hunter Station, June 20, 1978

Taxon	Stewart					Hunter				
	Rep 4	Rep 5	Rep 6	Mean	%RA	Rep 4	Rep 5	Rep 6	Mean	%RA
DIVISION BACILLARIOPHYTA (Diatoms)										
Achnanthes lanceolata						2,270			756	0.1
A. lanceolata var. *dubia*	6,190	39,200	41,200	28,070	3.8	79,400	43,100	61,200	61,250	7.6
A. minutissima	39,200	53,600	70,100	54,310	7.2	68,000	70,300	49,900	62,760	7.8
Amphora sp.		2,060		687	0.1	4,540		6,810	2,269	0.3
Cocconeis pediculus	P	P	2,060	687	0.1	2,270	2,270		1,513	0.2
C. placentula						6,810	P	4,540	3,781	0.5
Cyclotella meneghiniana	2,060	P	10,300	4,120	0.5					
Cymbella minuta	P		P	P						
C. sp.		P		P						
Fragilaria crotonensis			P	P						
F. sp.	2,060			687	0.1		6,810		2,269	0.3
Gomphonema intricatum var. *vibrio*	P			P				2,270	756	0.1
G. olivaceum	14,400	18,600	8,250	13,750	1.8	25,000	4,540	6,810	12,100	1.5
G. parvulum	6,190	6,190	2,060	4,812	0.6		P	2,270	756	0.1
G. spp.	2,060	4,120		2,060	0.3	9,070			3,025	0.4
Hannaea arcus		P		P						
Hantzschia amphioxys		P	P	P						
Navicula cryptocephala var. *veneta*	18,600	26,800	26,800	24,060	3.2	6,810			2,269	0.3
N. minima	12,400	14,400	18,600	15,120	2.0	4,540	6,810	13,600	8,320	1.0
N. secreta var. *apiculata*	57,700	74,200	66,000	66,000	8.8	22,700	22,700	34,000	26,470	3.3
N. tripunctata var. *schizonemoides*							2,270		756	0.1
N. viridula var. *avenacea*	16,500	16,500	33,000	22,000	2.9	95,300	86,200	79,400	86,960	10.7
N. spp.		37,100	6190	14,440	1.9		6810		2269	0.3

Table A8.6.2-2 (Continued)

Taxon	Stewart					Hunter				
	Rep 4	Rep 5	Rep 6	Mean	%RA	Rep 4	Rep 5	Rep 6	Mean	%RA
Nitzschia acicularis	53,600	53,600	82,500	63,250	25.2	216,000	284,000	263,000	254,100	31.4
N. apiculata			P	P						
N. dissipata		4,120	2,060	2,060	0.3	13,600	2,270	15,900	10,590	1.3
N. hungarica	2,060	2,060	4,120	2,750	0.4		2,270		756	0.1
N. linearis			6,190	2,062	0.3					
N. palea	72,200	78,400	51,600	67,370	8.9	61,200	122,000	93,000	92,200	11.4
N. sigmoidea							P		P	
N. spp.	315,500	338,200	286,700	313,500	41.6	83,900	188,000	141,000	137,600	17.0
Surirella angustata	P		P	P				2,270	756	0.1
S. ovalis	P	P	2,060	687	0.1		P	4,540	1,512	0.2
S. ovata	8,250	4,120	8,250	6,875	0.9	13,600	4,540	4,540	7,562	0.9
Synedra ulna	6,190	P		2,062	0.3					
S. sp.		4,120		1,406	0.2	2,270			756	0.1
Unidentified centrics	2,060	2,060		1,375	0.2			2,270	756	0.1
Unidentified pennates	22,700	43,300	24,700	30,250	4.0	9,070	13,600	31,800	18,150	2.2
Total Bacillariophyta	660,600	823,000	753,000	745,200	98.9	726,000	869,000	819,000	804,600	99.4
DIVISION CHLOROPHYTA (Green algae)										
Oedogonium sp.			2,060	687	0.1					
Scenedesmus sp.						2,270			756	0.1
Stigeoclonium sp.		2,060		687	0.1	2,270	4,540		2,269	0.3
Ulothrix sp.		2,060	P	687	0.1					
Unidentified filament	16,500	2,060	P	6,187	0.8					
Total Chlorophyta	16,500	6,190	2,060	8,249	1.1	4,540	4,540		3,025	0.4

Table A8.6.2-2 (Continued)

Taxon	Stewart					Hunter				
	Rep 4	Rep 5	Rep 6	Mean	%RA	Rep 4	Rep 5	Rep 6	Mean	%RA
DIVISION CYANOPHYTA (Blue-green algae)										
Chroococcus sp.		P		P						
Oscillatoria sp.							4,540		1,512	0.2
Total Cyanophyta		P		P			4,540		1,512	0.2
Total Individuals	676,000	829,000	755,000	753,400		730,000	878,000	819,000	809,100	
Total Taxa	25	31	28	39		21	23	19	32	
Diversity ($\bar{d}$)	2.87	3.13	3.17	3.15		3.27	2.86	3.09	3.14	
Maximum diversity ($\bar{d}$ max)	4.32	4.52	4.39	4.95		4.39	4.25	4.25	4.95	
Equitability (%)	66.44	69.29	72.17	63.55		74.40	67.45	72.65	63.35	

P = present

Table A8.6.2-3

Abundance (units/cm^2), Percent Relative Abundance (%RA), and Species Diversity of Periphyton from Artificial Substrates on Piceance Creek, Colorado, at Stewart and Hunter Stations, July 19, 1978

Taxon	Stewart					Hunter				
	Rep 1	Rep 2	Rep 3	Mean	%RA	Rep 1	Rep 2	Rep 3	Mean	%RA
DIVISION BACILLARIOPHYTA (Diatoms)										
Achnanthes lanceolata	18,974	22,769	92,972	44,905.0	9.0	34,153	18,974	14,230	22,452.3	5.9
A. lanceolata var. *dubia*	177,406	200,175	235,276	204,285.7	41.1	83,485	124,279	93,921	100,561.7	26.4
A. minutissima	203,021	123,330	192,585	172,978.7	34.8	135,663	142,304	159,380	145,782.3	38.3
Amphora perpusilla	2,846	1,897	5,692	3,478.3	0.7	949	949		632.7	0.2
A. sp.		P	P	P	-	P	P		P	-
Cocconeis pediculus	P	949	17,077	6,008.7	1.2	P	949	P	316.3	0.1
C. placentula var. *euglypta*	3,795	1,897	1,897	2,529.7	0.5	15,179	13,282	12,333	13,598.0	3.6
Cyclotella meneghiniana			949	316.3	0.1		P	2,846	948.7	0.2
nr. *Cylindrotheca gracilis*						P		P	P	-
Cymbella affinis	P			P	-					
C. minuta	949	P		316.3	0.1					
C. sp.			2,846	948.7	0.2					
Fragilaria vaucheriae	949			316.3	0.1					
Gomphonema gracile						P			P	-
G. olivaceum						949	2,846	P	1,265.0	0.3
G. parvulum	19,923	11,384	7,590	12,965.7	2.6	4,743	3,795	949	3,162.3	0.8
Navicula cryptocephala var. *veneta*		949	9,487	3,478.7	0.7	4,743	1,897	2,846	3,162.3	0.8
N. nr. *luzonensis*	6,641	4,743	10,436	7,273.3	1.5	18,025	13,282	3,795	11,700.7	3.1
N. notha		2,846		948.7	0.2					
N. secreta var. *apiculata*	3,795	3,795	7,590	5,060.0	1.0	12,333	16,128	14,230	14,230.3	3.7
N. tripunctata var. *schizonemoides*	P		949	316.3	0.1		P		P	-
N. viridula var. *avenacea*	2,846		P	948.7	0.2	8,538	6,641	7,590	7,589.7	2.0

Table A8.6.2-3 (Continued)

Taxon	Stewart Rep 1	Rep 2	Rep 3	Mean	%RA	Hunter Rep 1	Rep 2	Rep 3	Mean	%RA
N. spp.	2,846	949		1,265.0	0.2	7,590	4,743		4,111.0	1.1
Nitzschia acicularis						P		949	316.3	0.1
N. amphibia	949	2,846	949	1,581.3	0.3		949	949	632.7	0.2
N. apiculata	P	P	P	P	-	P		1,897	632.3	0.2
N. linearis		949	P	316.3	0.1	P		P	P	-
N. spp.	1,897	3,795	6,641	4,111.0	0.8	8,538	5,692	9,487	7,905.7	2.1
Rhoicosphenia curvata		1,897	949	948.7	0.2	1,897	1,897		1,264.7	0.3
Surirella ovalis	949	P	P	316.3	0.1	949	949	949	949.0	0.2
S. ovata	P	949	P	316.3	0.1		P		P	-
S. sp.							P		P	-
Synedra ulna			P	P	-			P	P	-
Unidentified pennates	1,897	1,897	1,897	1,897.0	0.4	5,692	949	3,795	3,478.7	0.9
Total Bacillariophyta	449,683	388,017	595,780	477,826.7	96.0	343,428	360,504	330,146	344,692.7	90.5
DIVISION CHLOROPHYTA (Green algae)										
Cladophora sp.			2,846	948.7	0.2			P	P	-
Stigeoclonium sp.	5,692	8,538	13,282	9,170.7	2.0	11,384	38,896	49,332	33,204.0	8.7
Unidentified coccoid							949		316.3	0.1
Unidentified filament	18,025	5,692	2,846	8,854.3	1.8	2,846	949	3,795	2,530.0	0.7
Total Chlorophyta	23,717	14,230	18,974	18,973.7	3.8	14,230	40,794	53,127	36,050.3	9.5

Table A8.6.2-3 (Continued)

Taxon	Stewart Rep 1	Stewart Rep 2	Stewart Rep 3	Stewart Mean	Stewart %RA	Hunter Rep 1	Hunter Rep 2	Hunter Rep 3	Hunter Mean	Hunter %RA
DIVISION CYANOPHYTA (Blue-green algae)										
Chroococcus sp.			P	P	-					
Merismopedia tenuissima			P	P	-					
Oscillatoria sp.			949	316.3	0.1					
Phormidium sp.		949	P	316.3	0.1			P	P	-
Total Cyanophyta		949	949	632.7	0.1			P	P	-
Total Individuals	473,399	403,196	615,703	497,432.7		357,658	401,298	383,273	380,743.0	
Total Taxa	23	25	31	36		25	26	25	34	
Diversity ($\bar{d}$)	2.16	2.18	2.44	2.37		2.88	2.69	2.59	2.78	
Maximum diversity ($\bar{d}_{max}$)	4.17	4.39	4.39	4.91		4.17	4.39	4.17	4.58	
Equitability (%)	51.70	49.63	55.60	48.35		69.06	61.31	62.05	60.68	

P = present but not in count

Table A8.6.2-4

Abundance (units/cm^2), Percent Relative Abundance (%RA), and Species Diversity
of Periphyton from Artificial Substrates on Piceance Creek, Colorado,
at Stewart and Hunter Stations, August 18, 1978

Taxon	Stewart					Hunter				
	Rep 1	Rep 2	Rep 3	Mean	%RA	Rep 1	Rep 2	Rep 3	Mean	%RA
DIVISION BACILLARIOPHYTA (Diatoms)										
Achnanthes lanceolata	1,107	2,372	1,739	1,739.3	3.3	9,487	7,590	9,487	8,854.7	3.1
A. lanceolata var. *dubia*	16,760	13,756	20,081	16,865.7	32.0	36,999	100,562	61,665	66,408.7	23.2
A. minutissima	3,953	5,099	11,226	6,759.3	12.8	116,690	41,742	116,690	91,707.3	32.1
Amphora perpusilla	632	593	158	461.0	0.9	16,128	4,743	8,538	9,803.0	3.4
A. sp.	474	949	949	790.7	1.5	949	P	P	316.3	0.1
Cocconeis pediculus	1,739	4,743	10,594	5,692.0	10.8	61,665	14,230	30,358	35,417.7	12.4
C. placentula var. *euglypta*	4,111	4,506	6,166	4,927.7	9.4	12,333	28,461	11,384	17,392.7	6.1
Cyclotella meneghiniana	790	356	316	487.3	0.9	949	2,846	2,846	2,213.7	0.8
Cymatopleura elliptica						P			P	-
Cymbella affinis		118		39.3	0.1			949	316.3	0.1
C. minuta		237		79.0	0.2					
Fragilaria vaucheriae						1,897			632.3	0.2
Gomphonema olivaceum		474	316	263.3	0.5		949	4,744	1,897.7	0.6
G. parvulum	474	712	1,265	817.0	1.6	2,846	3,795	2,846	3,162.3	1.1
G. spp.			316	105.3	0.2	949			316.3	0.1
Gyrosigma sp.			158	52.7	0.1		P		P	-
Hantzschia amphioxys	P			P	-					
Meridion circulare						P			P	-
Navicula capitata		P		P	-					
N. cryptocephala	P			P	-	949			316.3	0.1
N. cryptocephala var. *veneta*	474	2,846	3,637	2319.0	4.4		1,897	949	948.7	0.3
N. nr. *luzonensis*	474	356	1,107	645.7	1.2					
N. notha	158	1,067	474	566.3	1.1	2,846	1,897	P	1,581.0	0.6
N. secreta var. *apiculata*	1,107	4,981	4,269	3,452.3	6.6	3,795	9,487	8,538	7,273.3	2.5

Table A8.6.2-4 (Continued)

Taxon	Stewart					Hunter				
	Rep 1	Rep 2	Rep 3	Mean	%RA	Rep 1	Rep 2	Rep 3	Mean	%RA
N. tripunctata var. *schizonemoides*	632	356	474	487.3	0.9	P		2,846	948.7	0.3
N. viridula var. *avenacea*		356	158	171.3	0.3	6,641	10,436	15,179	10,752.0	3.8
N. spp.	632	1,186		606.0	1.2		4,743	2,846	2,529.7	0.9
Nitzschia acicularis						P		949	316.3	0.1
N. amphibia		P	158	52.7	0.1	949	949	949	949.0	0.3
N. apiculata		118	316	144.7	0.3	1,897	2,846	2,846	2,529.7	0.9
N. dissipata						949			316.3	0.1
N. linearis						P	1,897		632.3	0.2
N. vermicularis						P			P	-
N. spp.	1,265	1,542	1,581	1,462.7	2.8	5,692	7,590	10,436	7,906.0	2.8
Rhoicospheria curvata	158		158	105.3	0.2					
Surirella ovalis	P	474	158	210.7	0.4	P	949	P	316.3	0.1
S. ovata		118		39.3	0.1	P	1,897	3,795	1,897.3	0.7
S. spp.								P	P	-
Synedra ulna						949	949	P	632.7	0.2
Unidentified centrics	158	118	474	250.0	0.5					
Unidentified pennates	1,107	1,542	790	1,146.3	2.2	5,692		10,436	5,376.0	1.9
Total Bacillariophyta	36,210	48,977	67,042	50,743.0	96.4	291,249	250,455	309,275	283,659.7	99.2
DIVISION CHLOROPHYTA (Green algae)										
Characium sp.			474	158.0	0.3					
Cladophora sp.	158		316	158.0	0.3	949		1,897	948.7	0.3
Closterium sp.		118		39.3	0.1					
Stigeoclonium sp.	632	118		250.0	0.4					
Unidentified filament	790	712	1,265	922.3	1.5		949	2,846	1,265.0	0.4
Total Chlorophyta	1,580	948	2,055	1,527.7	2.6	949	949	4,743	2,213.7	0.8

Table A8.6.2-4 (Continued)

	Stewart					Hunter				
Taxon	Rep 1	Rep 2	Rep 3	Mean	%RA	Rep 1	Rep 2	Rep 3	Mean	%RA
DIVISION CYANOPHYTA (Blue-green algae)										
Merismopedia punctata		118		39.3	0.1					
Phormidium sp.						P	P		P	-
Total Cyanophyta		118		39.3	0.1	P	P		P	-
DIVISION CHRYSOPHYTA (Yellow-brown algae)										
Dinobryon borgei	316	356	316	329.3	0.6					
Total Chrysophyta	316	356	316	329.3	0.6					
Total Individuals	38,106	50,399	69,413	52,639.3		292,198	251,404	314,018	285.873.3	
Total Taxa	26	32	29	39		30	25	28	37	
Diversity ($\bar{d}$)	3.15	3.72	3.39	3.59		2.83	3.04	3.15	3.32	
Maximum diversity ($\bar{d}_{max}$)	4.52	4.91	4.86	5.17		4.46	4.46	4.52	5.04	
Equitability (R)	69.54	75.77	69.73	69.51		63.46	68.21	69.58	65.88	

P = present but not in count

Table A8.6.2-5

Abundance (units/cm^2), Percent Relative Abundance (%RA) and Species Diversity
of Periphyton from Artificial Substrates on Piceance Creek, Colorado,
at Stewart and Hunter Stations, September 20, 1978

	Stewart					Hunter				
Taxon	Rep 1	Rep 2	Rep 3	Mean	%RA	Rep 1	Rep 2	Rep 3	Mean	%RA
DIVISION BACILLARIOPHYTA										
Achnanthes lanceolata	10,587	7,562	4,537	7,562.0	1.8			SAMPLER DESTROYED		
A. lanceolata var. *dubia*	3,025	P	1,512	1,512.3	0.4					
A. minutissima	323,656	302,482	453,724	359,954.0	83.7					
Amphora veneta		1,512		504.0	0.1					
A. sp.	P	P	1,512	503.3	0.1					
Cocconeis pediculus	48,397	13,612	19,661	27,223.3	6.3					
C. placentula var. *euglypta*	6,050	6,050	3,025	5,041.7	1.2					
Cymbella minuta	3,025	P	P	1,008.3	0.2					
Gomphonema subclavatum		P		P						
G. truncatum			4,537	1,512.3	0.4					
G. spp.	1,512	3,025	1,512	2,016.3	0.5					
Navicula cryptocephala var. *veneta*	12,099	P	3,025	5,041.3	1.2					
N. secreta var. *apiculata*	1,512	1,512	3,025	2,016.3	0.5					
N. viridula var. *avenacea*		P		P						
N. spp.	3,025			1,008.3	0.2					
Nitzschia spp.	7,562	15,124	4,537	9,074.3	2.1					
Unidentified pennates	4,537	4,537	1,512	3,528.7	0.8					
Total Bacillariophyta	424,988	355,417	502,121	427,508.7	99.4					
DIVISION CHLOROPHYTA										
Oedogonium sp.		P								
Stigeoclonium sp.	P	P	1,512	504.0	0.1					
Unidentified coccoid		6,050		2,016.7	0.5					
Total Chlorophyta	P	6,050	1,512	2,520.7	0.6					

Table A8.6.2-5 (Continued)

Taxon	Stewart					Hunter				
	Rep 1	Rep 2	Rep 3	Mean	%RA	Rep 1	Rep 2	Rep 3	Mean	%RA
DIVISION CYANOPHYTA										
Merismopedia punctata			P	P				SAMPLER DESTROYED		
Phormidium sp.	P	P		P						
Total Cyanophyta	P	P	P	P						
DIVISION CHRYSOPHYTA										
Dinobryon sp.			P	P						
Total Chrysophyta			P	P						
Total Individuals	424,988	361,467	503,633	430,029.3						
Total Taxa	15	19	16	22						
Diversity ($\bar{d}$)	1.40	1.10	0.76	1.14						
Maximum Diversity ($\bar{d}$ max)	3.58	3.32	3.70	4.09						
Equitability (%)	39.19	33.20	20.55	27.77						

P = Present

Table A8.6.2-6

Abundance (units/cm^2), Percent Relative Abundance (%RA) and Species Diversity
of Periphyton from Artificial Substrates on Piceance Creek, Colorado,
at Stewart and Hunter Stations, October 18, 1978

	Stewart					Hunter				
Taxon	Rep 1	Rep 2	Rep 3	Mean	%RA	Rep 1	Rep 2	Rep 3	Mean	%RA
DIVISION BACILLARIOPHYTA (Diatoms)										
Achnanthes lanceolata		2,269	P	756.3	0.2		1,138		379.3	0.6
A. lanceolata var. dubia	3,403	4,537		2,646.7	0.7	9,107	3,415	3,890	5,470.7	8.5
A. minutissima	284,712	309,666	243,876	279,418.0	74.8	1,708	1,328	569	1,201.7	1.9
Amphora ovalis	P	1,134	2,269	1,134.3	0.3		190	95	95.0	0.1
A. perpusilla						379			126.3	0.2
Caloneis amphisbaena		P		P		P		95	31.7	<0.1
Cocconeis pecidulus	28,358	23,820	29,492	27,223.3	7.3	4,933	3,605	2,656	3,731.3	5.8
C placentula	5,672	18,149	3,403	9,074.7	2.4	P			P	
C. placentula var. euglypta		P		P		17,076	20,871	14,230	17,329.3	26.9
Cyclotella meneghiniana		2,269	3,403	1,890.7	0.5	1,897	1,138	1,138	1,391.0	2.2
Cylindrotheca gracilis								P	P	
Cymatopleura elliptica								P	P	
Cymbella minuta	2,269	1,134	5,672	3,025.0	0.8					
C. tumida	P	P	3,403	1,134.3	0.3					
Diatoma tenue var. elongatum	4,537	P	P	1,512.3	0.4					
D. vulgare		P	P	P						
Epithemia turgida		P		P						
Fragilaria crotonensis		P		P						
Gomphonema acuminatum	1,134			378.0	0.1					
G. olivaceum	1,134		3,403	1,512.3	0.4	949	569	379	623.3	1.0
G. parvulum	1,134	1,134		756.0	0.2	190		95	95.0	0.1
G. subclavatum	P			P						
G truncatum	1,134	5,672	22,686	9,830.7	2.6					

Table A8.6.2-6 (Continued)

Taxon	Stewart					Hunter				
	Rep 1	Rep 2	Rep 3	Mean	%RA	Rep 1	Rep 2	Rep 3	Mean	%RA
G spp.	7,940	2,269	2,269	4,159.3	1.1		379	569	316.0	0.5
Gyrosigma sp.						P	P	95	31.7	<0.1
Melosira varians								95	31.7	<0.1
Navicula capitata		P		P						
N. cryptocephala var. *veneta*	7,940	1,134	17,015	8,696.3	2.3	2,467	759	3,131	2,119.0	3.3
N. pupula var. *rectangularis*								95	31.7	<0.1
N. secreta var. *apiculata*	2,269	10,209	21,418	10,965.3	2.9	8,918	4,174	6,356	6,482.7	10.0
N. tripunctata var. *schizonemoides*	1,134	2,269	1,134	1,512.3	0.4					
N. viridula var. *avenacea*	P	P	P	P		24,097	18,974	11,479	18,183.3	28.2
N. spp.			1,134	378.0	0.1	1,328	379	1,423	1,043.3	1.6
Nitzschia acicularis	P	P	1,134	378.0	0.1	190		190	126.7	0.2
N. apiculata		P	P	P		190	P	379	189.7	0.3
N. dissipata	P			P						
N. hungarica		P		P		190			63.3	0.1
N. sigmoidea						379	379	285	347.7	0.5
N. vitrea			P	P						
N. spp.	3,403	3,403	4,537	3,781.0	1.0	2,467	3,415	1,423	2,435.0	3.8
Pinnularia sp.		P	1,134	378.0	0.1					
Rhoicospheria curvata			P	P		379	190	190	253.0	0.4
Rhopalodia gibba var. *ventricosa*			P	P						
Stauroneis anceps		P		P						
Surirella ovalis							P		P	
S. ovata						379	190	95	221.3	0.3
S. sp.						P	P		P	
Synedra ulna	P	P	P	P			P		P	
S. sp.	3,403		1,134	1,512.3	0.4			P	P	
Unidentified pennates						759	759	2,087	1,201.7	1.9
Total Bacillariophyta	359,576	389,068	367,516	372,053.3	99.6	77,982	61,852	51,039	63,624.3	98.6

Table A8.6.2-6 (Continued)

Taxon	Stewart Rep 1	Rep 2	Rep 3	Mean	%RA	Hunter Rep 1	Rep 2	Rep 3	Mean	%RA
DIVISION CHLOROPHYTA (Green algae)										
Closterium sp.						P	P	P	P	
Oedogonium sp.		P		P		379	P		126.3	0.2
Scendesmus acutus			P	P						
Stigeoclonium sp.	2,269	1,134	1,134	1,512.3	0.4			190	63.3	0.1
Ulothrix sp.		P	P	P						
Unidentified flagellate		P		P						
Unidentified filament	P			P		379			126.3	0.2
Total Chlorophyta	2,269	1,134	1,134	1,512.3	0.4	758	P	190	316.0	0.5
DIVISION CYANOPHYTA (Blue-green algae)										
Chroococcus sp.								285	95.6	0.1
Unidentified filament			P	P						
Total Cyanophyta			P	P				285	95.0	0.1
DIVISION CHRYSOPHYTA										
Unidentified coccoid							1,518		506.0	0.8
Total Chrysophyta							1,518		506.0	0.8
Total Individuals	361,845	390,202	368,651	373,566.0		78,742	63,373	51,514	64,543.0	
Total Taxa	24	34	31	44		27	26	30	40	
Diversity ($\bar{d}$)	1.43	1.37	2.03	1.7057		3.08	2.87	3.25	3.15	
Maximum diversity ($\bar{d}$ max)	4.09	4.00	4.25	4.58		4.46	4.25	4.70	5.00	
Equitability (%)	35.06	34.32	47.89	37.20		68.99	67.62	69.10	69.92	

P = present but not encountered while counting

Table A8.6.2-7

Summary Species List of Periphyton Collected at Stewart and Hunter Stations, Piceance Creek, Colorado, 1978

	Stewart						Hunter					
Taxon	May	June	July	Aug	Sept	Oct	May	June	July	Aug	Sept	Oct
Division Bacillariophyta												
Achnanthes lanceolata			D	+	+	+		+	D	+		+
A. lanceolata var. *dubia*	+	+	D	D	+	+	+	D	D	D		D
A. minutissima	+	D	D	D	D	D	D	D	D	D		+
Amphora ovalis						+						+
A. perpusilla			+	+					+	+		+
A. veneta					+							
A. sp.		+	+	+	+		+	+	+	+		
Caloneis amphisbaena						+						+
Cocconeis pediculus		+	+	D	D	D		+	+	D		D
C. placentula	+					+	+	+				+
C. placentula var. *euglypta*			+	D	+	+			+	D		D
Cyclotella meneghiniana		+	+	+		+			+	+		+
nr. *Cylindrotheca gracilis*									+			+
Cymatopleura elliptica										+		+
Cymbella affinis			+	+						+		
C. minuta	+	+	+	+	+	+						
C. tumida						+	+					
C. sp.		+	+									
Denticula sp.							+					
Diatoma tenue var. *elongatum*						+						
D. vulgare						+						
Epithemia turgida						+						
Fragilaria crotonesis	+	+				+						
F. vaucheriae	+		+									
F. sp.		+						+		+		
Gomphonema acuminatum						+					SAMPLER DESTROYED	
G. gracile							+		+			
G. intricatum var. *vibrio*		+						+				
G. olivaceum	+	+		+		+	+	+	+	+		+
G. parvulum	+	+	+	+		+	+	+	+	+		+
G. subclavatum					+	+						
G. subclavatum var. *commutatum*							+					
G. truncatum					+	+						
G. spp.	+	+		+	+	+	+	+		+		+
Gyrosigma sp.		+										+
Hantzschia amphioxys	+	+		+			+					
Melosira varians	+											+
Meridion circulare	+									+		
Navicula accomoda	+											
N. capitata	+			+		+	+					
N. cryptocephala	+			+			+			+		
N. cryptocephala var. *veneta*	D	+	+	+	+	+	D	+	+	+		+
N. cuspidata	+											
N. nr. *luzonensis*			+	+					+			
N. nr. *menisculus* var. *upsaliensis*							+					
N. minima	+	+					+	+				
N. mutica								+				
N. mutica var. *undulata*	+											
N. notha			+	+						+		
N. pupula var. *rectangularis*												+
N. secreta var. *apiculata*	D	D	+	D	+	+	D	+	+	+		D
N. tripunctata var. *schizonemoides*	D		+	+		+	D	+	+	+		
N. viridula var. *avenacea*	+	+	+	+		+	+	D	+	+		D
N. spp.	D	+	+	+	+	+	D	+	+	+		+
Neidium sp.	+											
Nitzschia acicularis	+	D				+	+	D	+	+		+
N. amphibia			+	+					+	+		
N. apiculata	+	+	+	+		+	+		+	+		+
N. dissipata	+	+				+	+	+		+		
N. hungarica	+	+				+		+				+
N. linearis		+	+						+	+		
N. palea	D	D					D	D				
N. sigmoidea	+						+	+				+
N. tryblionella var. *levidensis*	+											
N. vermicularis										+		
N. vitrea						+						
N. spp.	D	D	+	+	+	+	D	D	+	+		+

Table A8.6.2-7 (Continued)

Taxon	Stewart						Hunter					
	May	June	July	Aug	Sept	Oct	May	June	July	Aug	Sept	Oct
Division Bacillariophyta (cont'd)												
Pinnularia borealis	+											
P. sp.	+					+						
Rhoicosphenia curvata			+	+		+			+			+
Rhopalodia gibba var. *ventricosa*	+					+						
R. musculus	+											
Stauroneis anceps						+						
Stephanodiscus hantzschi	+											
Surirella angustata	+	+						+				
S. ovalis	+	+	+	+			+	+	+	+		+
S. ovata	+	+	+	+			+	+	+	+		+
S. sp.									+	+		+
Synedra delicatissima	+											
S. fasciculata							+					
S. ulna	+	+	+			+			+	+		+
S. sp.	+	+				+	+	+				+
Unidentified centrics		+		+			+	+				
Unidentified pennates	D	+	+	+	+		D	+	+	+		+
Division Chlorophyta											SAMPLER DESTROYED	
Characium sp.				+								
Cladophora sp.			+	+					+	+		
Closterium sp.				+								+
Crucigenia quadrata							+					
Oedogonium sp.		+			+	+						+
Scenedesmus acutus						+						
S. sp.								+				
Stigeoclonium sp.		+	+	+	+	+	+	+	+			+
Ulothrix sp.		+				+						
Unidentified coccoid					+		+		+			
Unidentified filament		+	+	+		+			+	+		+
Unidentified flagellate						+						
Division Cyanophyta												
Chroococcus sp.		+	+									+
Merismopedia punctata				+	+							
Merismopedia tenuissima			+									
Oscillatoria sp.	+		+					+				
Phormidium sp.			+	+					+	+		
Unidentified filament						+						
Division Cryptophyta												
Cryptomonas ovata							+					
Division Chrysophyta												
Dinobryon borgei				+								
D. sp.					+							
Unidentified coccoid												+

\+ = Present

D = Present as dominant (greater than 5% of the mean total abundance)

Table A8.6.2-8

Summary of Species Diversity ($\bar{d}$) of the Mean for Periphyton Collected at Stewart and Hunter Stations, Piceance Creek, Colorado, 1978.

Date	Stewart	Hunter
May	3.67	3.70
June	3.15	3.14
July	2.37	2.78
August	3.59	3.32
September	1.14	Sampler Destroyed
October	1.70	3.15

Table A8.6.2-9

Summary of Mean Biomass (mg/cm^2) Expressed as Ash-free Dry Weight for Periphyton Collected at Stewart and Hunter Stations, Piceance Creek, Colorado, 1978.

Date	Stewart	Hunter
May	0.52	0.66
June	0.42	1.66
July	0.24	0.37
August	0.05	0.28
September	0.35	Sampler Destroyed
October	0.13	0.22

Station

TABLE A8.6.2-10

P-3 TAXA	1974 AUG	SEP	OCT	NOV	DEC	1975 JAN	MAR	MAY	JUL	SEP	NOV	1976 JAN	MAR	MAY	JUL
CHLOROPHYCEAE															
Actinastrum sp.															
Cladophora sp.															
Chaetophora sp.															
Closterium sp.				X											
Closterium liebleinii															
Closterium lunula															
Closterium gracilis															
Cosmarium sp.															
Enteromorpha sp.															
Microspora sp.															
Pediastrum sp.															
Protococcus sp.															
Protococcus viridis															
Protoderma viride													X		
Scenedesmus sp.			X												
Spirogyra sp.															
Stigeoclonium sp.				X											
Ulothrix sp.													X		
Ulothrix zonata															
Vaucheria sp.				X											
Zygnema sp.															
Draparnaldia sp.															
Unidentified Zygnemataceaen															
Unidentified Green Coccoid															
BACILLARIOPHYCEAE															
Achnanthes sp.												X	X		X
Achnanthes lanceolata															
Achnanthes lanceolata var. *Dubia*															
Amphora sp.		X	X	X											
Amphora ovalis									X		X		X	X	X
Amphiphora ornata															
Asterionella sp.															
Caloneis sp.		X	X												
Caloneis amphisbaena									X						
Caloneis silicula									X						
Ceratoneis sp.															
Cocconeis sp.			X	X											
Cocconeis placentula									X	X	X	X		X	X
Cymbella sp.		X	X												
Cymbella affinis									X						
Cymbella ventricosa										X	X				
Cymbella tumida															X
Cyclotella sp.															
Cyclotella meneghiniana															
Cymatopleura sp.				X											
Cymatopleura solea									X				X		
Deploneis sp.															
Diatoma sp.				X											
Diatoma vulgare									X				X		X
Diatoma tenua var. *Elongatum*															
Eunotia sp.															
Eunotia pectinalis													X		
Fragilaria sp.				X											
Fragilaria crotonensis									X						X
Fragilaria construens		X													

TABLE A8.6.2-10 (CONTINUED)

Station

P-3 TAXA		1974						1975					1976		
	AUG	SEP	OCT	NOV	DEC	JAN	MAR	MAY	JUL	SEP	NOV	JAN	MAR	MAY	JUL
Frustulia sp.		X	X	X											
Gomphoneis sp.		X													
Gomphonema sp.		X	X	X											
Gomphonema olivaceum										X		X			
Gomphonema constrictum									X				X	X	
Gyrosigma sp.		X	X	X											
Gyrosigma acuminatum															
Hannaea arcus															
Melosira sp.															
Meridion sp.															
Meridion circulare									X						
Navicula sp.		X	X	X											
Navicula cryptocephala									X	X	X		X	X	X
Navicula rhynochocephala										X		X	X	X	X
Navicula viridula									X	X	X	X	X		
Nodium sp.															
Nitzschia sp.		X		X											
Nitzschia gracilis													X		
Nitzschia sigmoidea															
Nitzschia acicularis															
Nitzschia palea									X					X	
Nitzschia paleacea															
Pinnularia sp.															
Pinnularia viridis									X					X	
Rhoicosphenia sp.		X													
Rhoicosphenia curvata			X												
Rhopalodia sp.															
Stauroneis sp.				X											
Stephanodiscus hantzschii									X			X			
Surirella sp.		X	X	X											
Surirella ovata									X						
Synedra sp.		X	X	X											
Synedra ulna									X			X			X
Synedra ulna var. *Impressa*															
Synedra rupens															
Tabellaria sp.		X	X	X											
CYANOPHYTA															
Agmenellum sp.															
Anabaena sp.															
Lyngbya sp.															
Lyngbya spirulinoidea															
Nodularia sp.															
Oscillatoria sp.															
Oscillatoria limnetica															
Oscillatoria limosa															
Phormidium sp.			X												
EUGLENOPHYCEAE															
Euglena acus															
TRACHEOPHYTA															
Naja sp.															
Ranunculus sp.															
Potamogeton sp.															
Mimulus sp.															
Rorippa sp.															
TOTAL NUMBER SPECIES/MONTH		13	15	17					17	6	5	7	12	7	9

TABLE A8.6.2-11

Station

P-6 TAXA	1974 AUG	SEP	OCT	NOV	DEC	1975 JAN	MAR	MAY	JUL	SEP	NOV	1976 JAN	MAR	MAY	JUL
CHLOROPHYCEAE															
Actinastrum sp.			X	X											
Cladophora sp.		X		X											
Chaetophora sp.															
Closterium sp.															
Closterium liebleinii															
Closterium lunula															
Closterium gracilis									X						
Cosmarium sp.															
Enteromorpha sp.															
Microspora sp.															
Pediastrum sp.															
Protococcus sp.															
Protococcus viridis															
Protoderma viride									X						
Scenedesmus sp.															
Spirogyra sp.															
Stigoclonium sp.															
Ulothrix sp.									X			X			
Ulothrix zonata															
Vaucheria sp.															
Zygnema sp.															
Draparnaldia sp.															
Unidentified Zygnemataceaen															
Unidentified Green Coccoid								X							
BACILLARIOPHYCEAE															
Achnanthes sp.				X											
Achnanthes lanceolata								X				X	X		
Achnanthes lanceolata var. *Dubia*															
Amphora sp.															
Amphora ovalis									X				X		X
Amphiphora ornata															
Asterionella sp.															
Caloneis sp.		X	X	X											
Caloneis amphisbaena									X					X	
Caloneis silicula															
Ceratoneis sp.															
Cocconeis sp.		X	X	X											
Cocconeis placentula								X	X		X	X	X		X
Cymbella sp.		X	X												
Cymbella affinis															
Cymbella ventricosa										X	X				
Cymbella tumida													X		
Cyclotella sp.															
Cyclotella meneghiniana															
Cymatopleura sp.			X												
Cymatopleura solea															X
Deploneis sp.		X													
Diatoma sp.		X													
Diatoma vulgare								X							
Diatoma tenua var. *Elongatum*									X						
Eunotia sp.															
Eunotia pectinalis															
Fragilaria sp.															
Fragilaria crotonensis												X	X		
Fragilaria construens									X						

TABLE A8.6.2-11 (CONTINUED)

Station

P-6 TAXA	1974					1975						1976			
	AUG	SEP	OCT	NOV	DEC	JAN	MAR	MAY	JUL	SEP	NOV	JAN	MAR	MAY	JUL
Frustulia sp.		X	X	X											
Gomphoneis sp.															
Gomphonema sp.		X		X											
Gomphonema olivaceum									X			X			
Gomphonema constrictum											X				X
Gyrosigma sp.		X	X	X											
Gyrosigma acuminatum															
Hannaca arcus															
Melosira sp.															
Meridion sp.		X													
Meridion circulare															
Navicula sp.		X	X	X											
Navicula cryptocephala								X	X	X	X	X		X	X
Navicula rhynochocephala												X	X		X
Navicula viridula								X	X	X		X	X	X	
Neidium sp.				X											
Nitzschia sp.		X	X	X											
Nitzschia gracilis								X							
Nitzschia sigmoidea															
Nitzschia acicularis									X						X
Nitzschia palea									X		X				X
Nitzschia paleacea															
Pinnularia sp.			X	X											
Pinnularia viridis															X
Rhoicosphenia sp.															
Rhoicosphenia curvata															
Rhopalodia sp.			X												
Stauroneis sp.															
Stephanodiscus hantzschii										X	X	X			
Surirella sp.		X		X											
Surirella ovata			X					X	X						
Synedra sp.		X		X											
Synedra ulna									X						X
Synedra ulna var. *Impressa*															
Synedra rupens								X	X						
Tabellaria sp.			X	X											
CYANOPHYTA															
Agmenellum sp.															
Anabaena sp.			X					X	X						
Lyngbya sp															
Lyngbya spirulinoidea										X					
Nodularia sp.															
Oscillatoria sp.															
Oscillatoria limnetica															
Oscillatoria limosa															
Phormidium sp.															
EUGLENOPHYCEAE															
Euglena acus															
SPERMATOPHYTA															
Naja sp.															
Ranunculus sp															
Potamogeton sp															
Mimulus sp															
Rorippa sp															
[illegible]		14	14	15				10	17	5	6	9	7	3	10

TABLE A8.6.2-12

PERIPHYTON PRODUCTIVITY[1] ESTIMATES FOR PICEANCE BASIN STATIONS, MAY 1975 - JULY 1976

	Months						
Station	May	July	Sept	Nov	Jan	March	May	July
P-1		.1136*	.7964	.0071				
P-2		.0852	.0520	.0074				
P-3		.1429	.4936	.0092	.0614	.3029	.8425	.0232
P-5		.2906	.1832*	.0255				
P-5A			1.9059	.9596				.4528
P-6	.0192	.0258	.0116	.0067	.0070	.1698	.0142	.0339
P-7	.0088	.0473	.2459	.0235**			1.0738	.0310
S-1	.1310	.0276	.0089	.1380	.0567	1.375	2.4874	
S-2	.0063	.0708	.0164				.7598	.0247
USL		.0283	.0249***	.1676				
LSL[2]			H =.2866 V =.0930	H =.2189 V =.1196	H = .1584 V = .2301**	H=.4601 V=.2575		
W-1	.0964		.0418	.2659			3.2297*** 2.0331	1.9171
W-2							4.1507	1.5682
W-3	.0215		.0758	.1648	.1025		.1411	.2365
UWL			.0360	.2780	.7124	1.8139	.3658**	.0640
LWL			.0641	.0713	.0594	.1129	.1819	.0165
WR-1			.4693	.1383**				
WR-2			.1893	.0613**			4.4029	

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1. Grams ash-free weight/m^2/day (average of three replicates exposed for approximately 30 days).
2. H = Horizontal slide, V - Vertical slide.

* One slide only
** Two slides only
*** Exposed for two months

Table A8.7.1-1 . Herb quadrat summaries for Plot 1-0. Based on data from 25 permanently located quadrats. June 1978. Values in percents. "?" indicates uncertain identification. ± Values are equal to the standard error of the mean.

Species	Mean Cover	Relative Cover	Range of Cover Values	Frequency
Agoseris glauca	0.1	0.01	0-1	16
Agropyron desertorum	3.6	0.25	0-20	40
Agropyron smithii	1.7	0.12	0-15	52
Antennaria rosea	0.7	0.05	0-6	20
Arabis holboellii	0.1	0.01	0-1	8
Artemisia ludoviciana	0.4	0.03	0-6	12
Aster fendleri	<0.1	<0.01	0-<1	4
Bouteloua gracilis	0.6	0.04	0-15	8
Bromus tectorum	0.8	0.06	0-3	88
Carex pennsylvanica	0.3	0.02	0-4	20
Chaenactis douglasii	0.1	0.01	<1-1	24
Chenopodium album	<0.1	<0.01	0-<1	12
Cryptantha sp.	0.1	0.01	<1-1	16
Descurainia pinnata	<0.1	<0.01	0-<1	8
Euphorbia robusta	<0.1	<0.01	0-<1	3
Festuca brachyphylla (?)	0.2	0.02	0-6	8
Gayophytum ramocissimum	<0.1	<0.01	0-<1	32
Ipomopsis aggregata	<0.1	<0.01	0-<1	4
Lappula redowskii	0.1	0.01	0-1	12
Lepidium densiflorum	<0.1	<0.01	0-<1	4
Lomatium orientale	<0.1	<0.01	0-<1	8
Lupinus argenteus	<0.1	<0.01	0-<1	4
Mentzelia dispersa	0.1	0.01	0-1	12
Oryzopsis hymenoides	3.2	0.22	0-15	76
Phlox longifolia	<0.1	<0.01	0-<1	8
Poa fendleriana	0.1	0.01	0-3	4
Polygonum sawatchense	<0.1	<0.01	0-<1	28
Sitanion longifolium	0.4	0.03	0-2	32
Stipa comata	1.6	0.11	0-9	28
Townsendia sericea	<0.1	<0.01	0-<1	4
Unknown grass	0.1	0.01	0-3	4
Artemisia tridentata	<0.1	<0.01	0-<1	20
Gutierrezia sarothrae	0.2	1.10	0-2	20
Pinus edulis			0-<1	4
Total Herb	12.3		1-30	100
Total Woody	0.2		0-2	40
Mosses	0.3		0-5	12
Crustose Lichen	1.0		0-10	40
Litter	76.0		8-100	100
Bare Soil	21.4		0-89	96
Rock	2.5		0-25	56

Mean No. of Herb Species per m^2 = 6.32 ± 0.55
Mean No. of Species per m^2 = 6.56 ± 0.55

Table A8.7.1-2 . Herb quadrat summaries for Plot 1-F. Based on data from 25 permanently located quadrats. June 1978. Values in percents. "?" indicates uncertain identification. ±Values are equal to the standard error of the mean.

Species	Mean Cover	Relative Cover	Range of Cover Values	Frequency
Agoseris glauca	0.1	0.38	0-1	12
Agropyron dasystachyum	0.3	1.54	0-5	8
Agropyron desertorum	4.2	20.35	0-30	44
Agropyron smithii	0.8	3.65	0-11	16
Antennaria parvifolia	<0.1	<0.01	0-<1	8
Antennaria rosea	0.1	0.58	0-2	12
Arabis holboellii	<0.1	<0.01	0-<1	8
Artemisia ludoviciana	0.1	0.19	0-1	4
Aster fendleri	0.2	0.96	0-4	16
Astragalus ceramicus	0.1	0.19	0-1	32
Bromus tectorum	0.6	2.69	0-5	68
Carex pennsylvanica	0.3	1.34	0-4	12
Chaenactis douglasii	<0.1	<0.01	0-<1	4
Chenopodium album	<0.1	<0.01	0-<1	12
Collinsia parviflora	0.0	0.19	0-1	4
Cryptantha sp.	<0.1	<0.01	0-<1	4
Delphinium nelsoni	0.0	0.19	0-1	4
Descurainia pinnata	<0.1	<0.01	0-<1	8
Draba reptans	<0.1	<0.01	0-<1	4
Erigeron nematophyllus	0.1	0.19	0-1	4
Festuca brachyphylla (?)	0.4	2.11	0-6	20
Gayophytum ramocissimum	<0.1	<0.01	0-<1	8
Haplopappus nuttallii	0.2	1.15	0-4	12
Koeleria gracilis	2.0	9.79	0-14	28
Lappula redowskii	0.3	1.34	0-5	20
Lepidium densiflorum	<0.1	<0.01	0-<1	4
Mentzelia dispersa	0.2	1.15	0-6	8
Microsteris micrantha	<0.1	<0.01	0-<1	4
Oryzopsis hymenoides	7.4	35.51	0-45	84
Phlox hoodii	1.1	5.18	0-8	36
Physaria floribunda	0.1	0.19	0-1	8
Poa fendleriana (?)	1.0	4.80	0-12	24
Polygonum sawatchense	<0.1	<0.01	0-<1	8
Senecio multilobatus	0.1	0.38	0-2	8
Sitanion longifolium	0.5	2.50	0-5	40
Stipa comata	0.1	0.58	0-3	8
Taraxacum officinale	<0.1	<0.01	0-<1	4
Tragopogon dubius	0.1	0.19	0-1	4
Zigadenus venenosus	<0.1	<0.01	0-<1	4

Table A8.7.1-2 . (Continued)

Species	Mean Cover	Relative Cover	Range of Cover Values	Frequency
Artemisia tridentata	<0.1	<0.01	0-<1	12
Chrysothamnus nauseosus	<0.1	<0.01	0-<1	4
Gutierrezia sarothrae	0.6	2.69	0-5	16
Total Herb	18.9		1-55	100
Total Woody	0.6		0-5	44
Mosses	0.1		0-1	4
Crustose Lichen	0.2		0-5	16
Litter	77.8		20-99	100
Bare Soil	20.8		0-80	96
Rock	1.4		0-30	12

Mean No. of Herb Species per m^2 = 6.48 ± 0.69
Mean Total No. of Species per m^2 = 6.64 ± 0.68

Table A8.7.1-3 . Herb quadrat summaries for Plot 2-0. Based on data from 25 permanently located quadrats. June 1978. Values in percents. "?" indicates uncertain identification. Values are equal to the standard error of the mean.

Species	Mean Cover	Relative Cover	Range of Cover Values	Frequency
Agoseris glauca	0.1	0.24	0-1	4
Agropyron desertorum	3.8	22.82	0-16	36
Agropyron smithii	0.8	5.10	0-12	16
Antennaria rosea	<0.1	<0.01	0-<1	4
Artemisia ludoviciana	0.1	0.24	0-1	4
Aster fendleri	0.1	0.73	0-2	24
Aster glaucodes (?)	0.2	1.21	0-5	4
Astragalus ceramicus	<0.1	<0.01	0-<1	4
Bouteloua gracilis	0.4	2.43	0-9	12
Bromus tectorum	4.7	28.64	0-15	96
Carex pennsylvanica (?)	1.2	7.28	0-30	4
Chenopodium album	<0.1	<0.01	0-<1	16
Crepis acuminata	0.1	0.24	0-1	8
Descurainia pinnata	<0.1	<0.01	0-<1	8
Festuca brachyphylla (?)	0.4	2.67	0-6	16
Gayophytum ramocissimum	0.1	0.73	0-1	48
Heterotheca villosa	1.2	7.28	0-30	4
Koeleria gracilis	0.5	3.16	0-8	8
Lappula redowskii	0.2	1.21	0-3	40
Lepidium montanum	<0.1	<0.01	0-<1	4
Microsteris micrantha	<0.1	<0.01	0-2	16
Oenothera trichocalyx	<0.1	<0.01	0-<1	4
Oryzopsis hymenoides	0.2	0.97	0-2	16
Phlox longifolia	0.5	2.91	0-10	12
Poa sp.	0.1	0.49	0-1	8
Polygonum sawatchense	<0.1	<0.01	0-<1	16
Salsola iberica	<0.1	<0.01	0-<1	8
Sisymbrium altissimum	0.2	0.97	0-4	4
Sisymbrium officinale	0.1	0.24	0-1	4
Sitanion longifolium	1.1	6.55	0-8	44
Sphaeralcea coccinea	0.1	0.49	0-2	4
Taraxacum officinale	0.1	0.49	0-2	4
Tragopogon dubius	<0.1	<0.01	0-<1	4
Unknown composite	0.2	1.21	0-5	4
Unknown mustard	0.1	0.49	0-2	8
Artemisia tridentata	0.2	1.21	0-2	28
Chrysothamnus nauseosus	<0.1	<0.01	0-1	24

Table A8.7.1-3. (Continued)

Species	Mean Cover	Relative Cover	Range of Cover Values	Frequency
Total Herbs	15.8		1-35	100
Total Woody	0.4		0-2	36
Mosses	0.1		0-3	4
Crustose Lichen	0.1		0-2	20
Litter	82.4		45-100	100
Bare Soil	15.9		0-45	84
Rock	1.6		0-25	24

Mean No. of Herb Species per m^2 = 5.04 ± 0.45
Mean Total No. of Species per m^2 = 5.56 ± 0.49

Table A8.7.1-4. Herb quadrat summaries for Plot 2-F. Based on data from 25 permanently located quadrats. June 1978. Values in percents. "?" indicates uncertain identification. (± values are equal to the standard error of the mean).

Species	Mean Cover	Relative Cover	Range of Cover Values	Frequency
Agoseris glauca	0.1	0.54	0-1	8
Agropyron dasystachyum	5.7	38.69	0-35	44
Agropyron desertorum	0.8	5.45	0-20	4
Agropyron smithii	0.6	4.36	0-6	24
Antennaria rosea	0.2	1.09	0-4	4
Aster fendleri	0.1	0.54	0-2	16
Astragalus ceramicus	<0.1	<0.01	0-<1	4
Astragalus diversifolius	0.1	0.27	0-1	4
Bouteloua gracilis	0.2	1.63	0-3	16
Bromus tectorum	2.7	18.53	0-20	76
Calochortus nuttallii	<0.1	<0.01	0-<1	4
Chenopodium album	<0.1	<0.01	0-<1	20
Erysimum asperum	<0.01	<0.01	0-<1	4
Festuca brachyphylla (?)	0.1	2.18	0-3	16
Gayophytum ramocissimum	0.1	0.82	0-1	32
Koeleria gracilis	0.6	3.81	0-9	12
Lappula redowskii	0.1	0.27	0-1	12
Lomatium grayi	0.1	0.27	0-1	4
Mentzelia dispersa	<0.1	<0.01	0-<1	4
Microsteris micrantha	<0.1	<0.01	0-<1	4
Phlox longifolia	0.1	0.27	0-1	8
Poa fendleriana	0.4	3.00	0-6	8
Poa pratensis	0.1	0.82	0-3	4
Polygonum sawatchense	<0.1	<0.01	0-<1	20
Oryzopsis hymenoides	0.9	5.99	0-5	24
Sitanion longifolium	1.0	7.08	0-7	36
Sphaeralcea coccinea	0.1	0.54	0-1	8
Stipa comata	0.2	1.63	0-6	4
Unknown mustard	<0.1	<0.01	0-4	4
Artemisia tridentata	0.2	1.63	0-3	44
Chrysothamnus nauseosus	0.1	0.27	0-1	12
Pinus edulis	0.1	0.27	0-1	4
Purshia tridentata	<0.1	<0.01	0-<1	4
Total Herb	12.6		1-40	100
Total Woody	0.3		0-3	56
Mosses	0.4		0-5	8
Crustose Lichen	0.6		0-8	20
Litter	81.8		25-100	100
Bare Soil	16.6		0-75	76
Rock	1.7		0-14	32

Mean No. of Herb Species per m^2 = 4.36±0.44
Mean Total No. of Species per m^2 = 4.96±0.46

Table A8.7.1-5 . Frequency, mean cover, and relative cover values for shrub species in plot 1-0, 1974-1978. Based on data from 20 10m x 4m line strip transects.

Species	Frequency (%)			Mean Cover (%)			Relative Cover (%)		
	1974	1976	1978	1974	1976	1978	1974	1976	1978
Amelanchier spp.	40	30	35	0.3	0.3	0.4	2.1	1.9	2.3
Artemisia tridentata	100	100	100	9.6	10.3	9.6	66.8	58.5	64.0
Cercocarpus montanus	65	65	70	0.4	0.3	0.2	3.1	1.9	1.1
Chrysothamnus nauseosus	30	45	40	0.4	0.2	0.2	2.8	1.2	1.0
Chrysothamnus viscidiflorus	5	15	15	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Juniperus osteosperma	40	35	45	0.6	0.4	2.0	3.8	2.3	13.1
Juniperus scopulorum	5	15		1.0	1.4		6.6	7.9	
Opuntia polyacantha	20	10	35	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Pinus edulis	55	70	75	0.8	1.6	1.2	5.5	9.2	8.1
Purshia tridentata	65	80	75	1.2	1.9	1.1	8.3	10.9	7.4
Symphoricarpos oreophilus	30	30	40	0.2	0.2	0.4	1.0	0.8	2.9
Total				14.5	16.6	15.1			

Table A8.7.1-6 . Frequency, mean cover, and relative cover values for shrub species in plot 1-F, 1974-1978. Based on data from 20 10m x 4m line strip transects.

Species	Frequency (%)			Mean Cover (%)			Relative Cover (%)		
	1974	1976	1978	1974	1976	1978	1974	1976	1978
Amelanchier spp.	10	10	15	0.6	0.8	0.7	6.6	6.3	7.0
Artemisia tridentata	80	80	100	5.3	7.4	6.4	58.6	58.6	61.7
Cercocarpus montanus	50	55	50	0.1	0.1	0.2	1.1	0.7	1.9
Chrysothamnus nauseosus	50	50	55	1.4	1.5	1.3	15.5	12.1	12.5
Chrysothamnus viscidiflorus	5	5		<0.1	<0.1		<0.1	<0.1	
Juniperus osteosperma	25	20	40	0.2	0.2	0.4	2.2	1.7	3.7
Juniperus scopulorum	5	5		<0.1	0.1		<0.1	1.0	
Opuntia polyacantha	10		20	<0.1		<0.1	<0.1		<0.1
Pinus edulis	25	25	25	0.2	0.2	0.3	2.8	1.9	2.6
Purshia tridentata	50	65	55	0.6	1.6	1.0	6.6	12.5	9.5
Symphoricarpos oreophilus	20	20	35	0.1	<0.1	0.1	1.1	<0.1	1.1
Total				8.5	11.9	10.4			

Table A8.7.1-7. Frequency, mean cover, and relative cover values for shrub species in plot 2-0, 1974-1978. Based on data from 20 10m x 4m line strip transects.

Species	Frequency (%)			Mean Cover (%)			Relative Cover (%)		
	1974	1976	1978	1974	1976	1978	1974	1976	1978
Amelanchier spp.	20	10	10	0.2	0.6	0.7	3.7	7.4	7.8
Artemisia tridentata	50	50	75	0.3	0.9	1.7	5.5	12.0	19.2
Cercocarpus montanus	25	25	25	0.3	0.2	0.2	5.5	1.9	2.5
Chrysothamnus nauseosus	85	90	95	2.6	3.4	4.2	46.7	42.8	46.9
Chrysothamnus viscidiflorus	5	10		<0.1	<0.1		<0.1	<0.1	
Juniperus osteosperma	50	60	60	1.3	1.2	0.9	23.9	15.6	10.6
Opuntia polyacantha	35		20	<0.1		<0.1	<0.1		<0.1
Pinus edulis	65	60	60	0.8	0.5	0.3	13.8	5.9	3.7
Purshia tridentata	20	25	35	<0.1	0.6	0.4	<0.1	7.0	4.6
Symphoricarpos oreophilus	10	20	35	0.1	0.1	0.4	0.9	0.8	4.6
Total				5.6	7.5	8.8			

Table A8.7.1-8. Frequency, mean cover, and relative cover values for shrub species in plot 2-F, 1974-1978. Based on data from 20 10m x 4m line strip transects.

Species	Frequency (%)			Mean Cover (%)			Relative Cover (%)		
	1974	1976	1978	1974	1976	1978	1974	1976	1978
Amelanchier spp.	30	10	10	<0.1	<0.1	<0.1	0.5	<0.1	<0.1
Artemisia tridentata	35	65	70	1.1	1.6	2.6	11.7	11.9	17.7
Artemisia sp.		5			<0.1			<0.1	
Cercocarpus montanus	10	25	20	0.4	0.5	0.5	4.3	3.7	3.8
Chrysothamnus nauseosus	50	70	75	0.6	1.8	1.4	6.9	12.9	9.5
Chrysothamnus viscidiflorus	5	10	5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Juniperus osteosperma	70	80	85	2.8	4.0	3.4	30.3	28.9	23.3
Opuntia polyacantha	10		15	<0.1		<0.1	<0.1		<0.1
Pinus edulis	65	65	70	1.2	1.9	1.9	12.2	13.6	12.8
Purshia tridentata	35	55	40	3.2	3.8	4.8	34.1	27.2	32.7
Symphoricarpos oreophilus		30	25		<0.1	0.1		<0.1	0.3
Total				9.3	13.6	14.7			

Table A8.7.1-9. Density values (No. per hectare) for shrub species at plots 1-0, 1-F, 2-0, and 2-F; chained pinyon-juniper rangeland. Values based on 20 10m x 4m belt transects. Height class 1 = 0.25m - 0.75m; class 2 = 0.76m - 1.50m; class 3 = 1.51m - 2.25m; class 4 = <2.26m. 1974-1978.

	Height Class	Plot 1-0			Plot 1-F			Plot 2-0			Plot 2-F		
		1974	1976	1978	1974	1976	1978	1974	1976	1978	1974	1976	1978
Amelanchier spp.	1	162	99	163	25	25	88	62	49	38	75	25	25
	2	25	49	113	12	12	13	12		25	25	12	13
	3								12				
	4									13			
	Total	187	148	276	37	37	101	74	61	76	100	37	38
Artemisia tridentata	1	2162	2561	2350	988	788	1138	138	151	575	212	388	700
	2	712	1074	1363	600	724	863	62	86	150	50	200	213
	3	12	25	38	12	49	150		12	25		49	63
	4			13			13						
	Total	2886	3661	3764	1600	1561	2164	200	249	735	262	637	976
Artemisia sp.	1											12	
	Total											12	
Cercocarpus montanus	1	262	375	350	138	138	100	38	62	75	50	62	100
	2	88	114	150	112	163	188	25	37	13		12	
	3					49	63	12	25		12	12	
	4								12	13		12	26
	Total	350	489	500	250	363	351	75	124	101	62	99	126
Chrysothamnus nauseosus	1	175	212	138	262	188	200	388	1037	1463	175	262	213
	2	25	12	13	12	62	50	100	225	163	50	114	100
	3									25			
	Total	200	224	151	272	250	250	488	1262	1651	225	376	313

Table A8.7.1-9. (Continued)

	Height Class	Plot 1-0			Plot 1-F			Plot 2-0			Plot 2-F		
		1974	1976	1978	1974	1976	1978	1974	1976	1978	1974	1976	1978
Chrysothamnus viscidiflorus	1	12	49	63	12	12		12	25		12	25	13
	Total	12	49	63	12	12		12	25		12	25	13
Juniperus osteosperma	1	75	37	88	38	49	88	75	74	75	200	138	150
	2	62	62	75	50	12	38	162	175	138	225	225	150
	3			50				12	37	50	12	37	88
	4			13							12	25	13
	Total	137	99	226	88	61	126	249	286	263	449	425	401
Juniperus scopulorum	1	25	12		12								
	2	25	25										
	Total	50	37		12								
Opuntia polyacantha	1	100	25	75	125		50	200		35	100		38
	Total	100	25	75	125		50	200		35	100		38
Pinus edulis	1	138	188	163	125	114	150	212	114	138	162	212	188
	2	125	200	125	38	49	38	75	126	75	138	225	113
	3	38	49	63	12	25	13	25	49	50	38	86	125
	4			25			13		12	38			38
	Total	301	437	376	175	188	214	312	301	301	338	523	464
Purshia tridentata	1	588	874	938	225	299	200	88	74	88	225	175	213
	2	12	1000	125	50	212	188	12	37	13	125	249	288
	3						13		12	13			50
	Total	600	1874	1063	275	511	401	100	123	114	350	424	551
Symphoricarpos oreophilus	1	150	262	438	112	62	188	112	99	188		49	125
	2			13		25	38			13		37	50
	Total	150	262	451	112	87	226	112	99	201		86	175

Table A8.7.2-1. Oven dry weights (grams) for range cages and adjacent open areas in the pinyon-juniper woodland community type. 1978.

	Quadrat Number	*Agropyron smithii*	*Bromus tectorum*	*Oryzopsis hymenoides*	Other Perennial Grasses	Perennial Forbs	Annual Forbs	Half Shrubs	Total Biomass
OPEN AREA	1	1.513	0.068		17.647	0.418	5.456		25.102
	2	0.281			2.037	0.261			2.579
	3	0.191			7.901	9.377	0.334		17.803
	4			4.931	2.560	0.880			8.371
	5				2.152	2.518			4.670
	6		0.011		3.597	0.188		2.926	6.722
	7				2.188	0.062	0.139		2.389
	8		0.645	8.968	4.483	0.248	0.771		15.115
	9								
	10			2.631		3.148			5.779
RANGE CAGES	1	6.488			55.936	6.000	2.249		70.673
	2			7.909	0.597	3.329			11.835
	3	0.427			7.002	8.197	1.059		16.685
	4			9.988	20.771	1.580	0.015		32.354
	5				12.719	5.970	0.002		18.691
	6				6.657	0.079	0.002		6.738
	7	0.212			6.848	0.222	0.139		7.421
	8				1.002	7.997			8.999
	9								
	10	0.631			10.669	8.034	0.008		19.342

Table A8.7.2-2. Mean production ± the standard error of the mean (S.E.), frequency, and range of observed values for clipped plots in the pinyon-juniper woodland community. Production values in grams/m^2. 1978.

	Mean ± S.E.	Sample Size	Frequency (%)	Range of Values
RANGE CAGES				
Agropyron smithii	0.862 ± 0.707	9	44	0-6.488
Oryzopsis hymenoides	1.989 ± 1.327	9	22	0-9.988
Other perennial grasses	13.578 ± 5.674	9	100	0.597-55.936
Perennial forbs	4.601 ± 1.121	9	100	0.079-8.197
Annual forbs	0.386 ± 0.260	9	78	0-2.249
Total	21.415 ± 6.705	9	100	6.738-70.673
OPEN AREAS				
Agropyron smithii	0.221 ± 0.165	9	33	0-1.513
Bromus tectorum	0.080 ± 0.071	9	33	0-0.645
Oryzopsis hymenoides	1.837 ± 1.063	9	33	0-8.968
Other perennial grasses	4.729 ± 1.770	9	89	0-17.647
Perennial forbs	1.900 ± 1.006	9	100	0.062-9.377
Annual forbs	0.744 ± 0.595	9	44	0-5.456
Half shrubs	0.325 ± 0.325	9	11	0-2.926
Total	9.837 ± 2.602	9	100	2.389-25.102

Table A8.7.2-3. Oven dry weights (grams) for range cases and adjacent open areas in the chained pinyon-juniper rangeland community type. 1978.

	Quadrat Number	*Agropyron smithii*	*Bromus tectorum*	*Oryzopsis hymenoides*	Other Perennial Grasses	Perennial Forbs	Annual Forbs	Half Shrubs	Total Biomass
OPEN AREA	1		10.766	7.433	5.489	3.855	0.460		28.003
	2	0.359	0.166		17.501	5.563	0.068		23.657
	3	11.931		0.699	47.329				59.959
	4	17.499	1.329	49.617	20.729				89.174
	5	3.646		65.528	16.432	0.398			86.004
	6		0.460	4.388	15.209	11.170	0.088		31.315
	7	52.547	0.551		7.339	0.015	0.006		60.458
	8	8.873			30.574	3.852	0.111		43.410
	9		0.058	0.877	30.417	25.785	0.076		57.213
	10								
RANGE CAGES	1	15.961	7.354	1.726	1.564		0.348		26.953
	2	4.816	0.483	7.894	13.087	0.363	0.028		26.671
	3	27.529		74.478	15.095				117.102
	4	6.747		52.070	75.576	9.018			143.411
	5	1.349		3.286	33.656				38.291
	6		0.425	55.143	10.048	4.145			69.761
	7	19.576	0.017	0.181	20.069	6.500	0.640		46.983
	8	9.696			59.015	1.014	0.147		69.872
	9	0.444			24.491	7.880			32.815
	10								

Table A8.7.2-4 . Mean production ± the standard error of the mean (S.E.), frequency, and range of observed values for clipped plots in the chained pinyon-juniper rangeland. Production values in grams/m^2. 1978.

	Mean ± S.E.	Sample Size	Frequency (%)	Range of Values
RANGE CAGES				
Agropyron smithii	9.569 ± 3.198	9	89	0-27.529
Bromus tectorum	0.920 ± 0.807	9	44	0-7.354
Oryzopsis hymenoides	21.642 ± 9.972	9	78	0-74.478
Other perennial grasses	28.067 ± 8.116	9	100	1.564-75.576
Perennial forbs	3.213 ± 1.242	9	67	0-9.018
Annual forbs	0.129 ± 0.075	9	44	0-0.640
Total	63.540 ± 13.885	9	100	26.671-143.411
OPEN AREAS				
Agropyron smithii	19.428 ± 10.358	9	67	0-52.547
Bromus tectorum	1.481 ± 1.169	9	67	0-10.766
Oryzopsis hymenoides	14.282 ± 8.330	9	67	0-65.528
Other perennial grasses	21.224 ± 4.357	9	100	5.489-47.329
Perennial forbs	5.626 ± 2.803	9	78	0-25.785
Annual forbs	0.090 ± 0.049	9	67	0-0.460
Total	53.244 ± 7.964	9	100	23.657-89.174

Table A8.7.2-5. Oven dry weights (grams) for range cages and adjacent open areas in the upland sagebrush community type. 1978.

	Quadrat Number	*Agropyron smithii*	*Bromus tectorum*	*Oryzopsis hymenoides*	Other Perennial Grasses	Perennial Forbs	Annual Forbs	Half Shrubs	Total Biomass
OPEN AREA	1	1.513			24.274	8.691		46.447	80.925
	2	1.981			13.875	0.105	0.005		15.966
	3	7.975	1.387	0.021	13.936	0.155	0.008		23.482
	4	29.125	0.807	1.765	28.673	2.886			63.256
	5	15.313	0.003		11.507	11.194	0.068		38.085
	6	4.252			81.377	6.931	0.023		92.583
	7	3.179	0.317		54.047	0.138	0.004		57.685
	8	9.584			11.209	4.420	0.123		25.336
	9	3.735			17.336	3.709		6.992	31.772
	10	13.852	0.192		27.445	1.178			42.667
RANGE CAGES	1				69.652	13.926	1.807	54.519	139.904
	2	3.143		2.443	25.071	0.191			30.848
	3	30.171			74.087	3.358	0.829		108.445
	4	18.072			34.241	0.499	0.003		52.815
	5	16.777			17.931	7.189			41.897
	6	12.633			43.941	1.258			57.832
	7	2.575			80.774	1.905	0.072		85.326
	8	23.282			23.215	0.281	0.270		47.048
	9	0.508			39.421	8.877			48.806
	10	12.916			41.559	12.853			67.328

Table A8.7.2-6. Mean production ± the standard error of the mean (S.E.), frequency, and range of observed values for clipped plots in the upland sagebrush community. Production values in grams/m^2. 1978.

	Mean ± S.E.	Sample Size	Frequency (%)	Range of Values
RANGE CAGES				
Agropyron smithii	12.008 ± 3.269	10	90	0-30.171
Oryzopsis hymenoides	0.244 ± 0.244	10	10	0-2.443
Other perennial grasses	44.989 ± 7.069	10	100	17.931-80.774
Perennial forbs	5.034 ± 1.677	10	100	0.191-13.926
Annual forbs	0.298 ± 0.187	10	50	0-1.807
Half shrubs	5.452 ± 5.452	10	10	0-54.519
Total	68.025 ± 10.703	10	100	30.848-139.904
OPEN AREAS				
Agropyron smithii	9.051 ± 2.706	10	100	1.513-29.125
Bromus tectorum	0.271 ± 0.148	10	50	0-1.387
Oryzopsis hymenoides	0.179 ± 0.176	10	20	0-1.765
Other perennial grasses	28.368 ± 7.154	10	100	11.209-81.377
Perennial forbs	3.941 ± 1.232	10	100	0.105-11.194
Annual forbs	0.023 ± 0.013	10	60	0-0.123
Half shrubs	5.344 ± 4.620	10	20	0-46.447
Total	47.176 ± 8.112	10	100	15.966-92.583

Table A8.7.2-7 . Oven dry weights (grams) for range cages and adjacent open areas in the bottomland sagebrush community type. 1978.

	Quadrat Number	*Agropyron smithii*	*Bromus tectorum*	*Oryzopsis hymenoides*	Other Perennial Grasses	Perennial Forbs	Annual Forbs	Half Shrubs	Total Biomass
OPEN AREA	1	1.144	2.566		12.138	7.799	11.485		35.132
	2	3.089	1.337		0.379				4.805
	3	9.624	5.012		0.299	5.288	1.405		21.628
	4		4.688		9.339		0.057	0.889	14.973
	5		1.714		0.702	2.219	0.849		5.484
	6		10.539						10.539
	7	2.203	3.954			0.249	0.123		6.529
	8	1.126	0.610	17.927	14.579	1.922	0.044		36.208
	9	0.522	2.992		2.902	0.338	0.086		6.840
	10	0.328	22.758			0.022	0.480		23.588
RANGE CAGES	1		8.863		15.956	16.439	0.074		41.332
	2	15.629			8.588		0.334		24.551
	3	14.435	3.691		0.029	28.408	5.202		51.765
	4		25.903		1.057	16.089	2.558	4.148	49.755
	5		24.151		3.858	0.107	0.521		28.637
	6		7.081		0.294		0.135		7.510
	7	3.450	2.112		38.429	0.018	0.113		44.122
	8	1.175	3.283		0.138	0.209	0.014	0.229	5.048
	9	2.411	13.581		0.701		0.115		16.808
	10		58.747			0.111	0.596		59.454

Table A8.7.2-8 . Mean production ± the standard error of the mean (S.E.), frequency, and range of observed values for clipped plots in the bottomland sagebrush community. Production values in grams/m^2. 1978.

	Mean ± S.E.	Sample Size	Frequency (%)	Range of Values
RANGE CAGES				
Agropyron smithii	3.710 ± 1.927	10	50	0-15.629
Bromus tectorum	14.741 ± 5.651	10	90	0-58.747
Other perennial grasses	6.905 ± 3.866	10	90	0-38.429
Perennial forbs	6.138 ± 3.265	10	70	0-28.408
Annual forbs	0.966 ± 0.528	10	100	.014-5.202
Half shrubs	0.438 ± 0.413	10	20	0-4.148
Total	32.898 ± 6.064	10	100	5.048-59.454
OPEN AREAS				
Agropyron smithii	1.804 ± 0.928	10	70	0-9.624
Bromus tectorum	5.617 ± 2.100	10	100	0.610-22.758
Oryzopsis hymenoides	1.793 ± 1.793	10	10	0-17.927
Other perennial grasses	4.032 ± 1.806	10	70	0-14.579
Perennial forbs	1.784 ± 0.855	10	70	0-7.799
Annual forbs	1.453 ± 1.124	10	80	0-11.485
Half shrubs	0.089 ± 0.089	10	10	0-0.887
Total	16.573 ± 3.802	10	100	4.805-36.208

Table A8.7.2-9. Regression equations used for converting fresh weight estimates to oven dry weights for the intensive study plots, May 1977.

Species / Species Group	Regression Equation	Correlation Coefficient
Agropyron smithii	$y = 0.512x + 0.717$	0.70
Bromus tectorum	$y = 0.435x + 0.185$	0.62
Oryzopsis hymenoides	$y = 0.362x + 1.134$	0.84
Other perennial grasses	$y = 0.543x + 0.720$	0.80
Perennial forbs	$y = 0.431x - 0.228$	0.62
Annual forbs	$y = 0.372x - 0.028$	0.68
Half shrubs*	$y = 0.379x$	
Total biomass	$y = 0.529x + 0.948$	0.82

*Only one data point

Table A8.7.2-10 Regression equations used for converting fresh weight estimates to oven dry weights for the intensive study plots, June 1977.

Species / Species Group	Regression Equation	Correlation Coefficient
Agropyron smithii	$y = 0.711x + 1.519$	0.75
Bromus tectorum[*]	$y = 0.435x + 0.185$	0.62
Oryzopsis hymenoides	$y = 0.920x + 0.065$	0.80
Other perennial grasses	$y = 0.323x + 1.554$	0.55
Perennial forbs	$y = 0.624x + 0.464$	0.86
Annual forbs	$y = 0.701x - 0.234$	0.99
Half shrubs	$y = 0.439x - 0.240$	0.92
Total biomass	$y = 0.697x + 1.517$	0.77

*Same equation as used for May data.

Table A8.7.2-11 Regression equations used for converting fresh weight estimates to oven dry weights for the intensive study plots, July 1977.

Species / Species Group	Regression Equation	Correlation Coefficient
Agropyron smithii	$y = 0.505x + 0.807$	0.70
Bromus tectorum*	$y = 0.435x + 0.185$	0.62
Oryzopsis hymenoides	$y = 0.870x - 0.592$	0.93
Other perennial grasses	$y = 0.605x + 0.512$	0.95
Perennial forbs	$y = 0.618x - 0.157$	0.94
Annual forbs	$y = 0.338x - 0.189$	0.96
Half shrubs	$y = 0.236x + 0.436$	0.98
Total biomass	$y = 0.591x + 0.805$	0.91

*Same equation as used for May data.

Table A8.7.2-12. Mean production ± the standard error of the mean (S.E.), frequency, and range of observed values for quadrats in Plots 1-O and 1-F, May 1977. Based on data derived from regression equations. Production values in grams/m^2.

	Mean ± S.E.	Sample Size	Frequency (%)	Range of Values
PLOT 1-O				
Agropyron smithii	0.025 ± 0.025	50	2	0-1.229
Bromus tectorum	0.067 ± 0.037	50	8	0-1.490
Oryzopsis hymenoides	1.089 ± 0.185	50	46	0-4.389
Other perennial grasses	5.992 ± 0.686	50	92	0-22.452
Perennial forbs	0.868 ± 0.229	50	58	0-6.238
Total	8.220 ± 0.689	50	96	0-22.106
PLOT 1-F				
Agropyron smithii	0.054 ± 0.040	50	4	0-1.741
Oryzopsis hymenoides	1.477 ± 0.219	50	62	0-5.836
Other perennial grasses	5.657 ± 0.682	50	96	0-22.452
Perennial forbs	1.112 ± 0.270	50	50	0-9.413
Total	8.465 ± 0.629	50	100	1.213-22.106

Table A8.7.2-13 Mean production ± the standard error of the mean (S.E.), frequency, and range of observed values for quadrats in Plots 1-0 and 1-F, June 1977. Based on data derived from regression equations. Production values in grams/m^2.

	Mean ± (S.E.)	Sample Size	Frequency (%)	Range of Values
PLOT 1-0				
Agropyron smithii	0.415 ± 0.255	50	10	0-12.180
Oryzopsis hymenoides	0.479 ± 0.196	50	30	0-9.263
Other perennial grasses	3.609 ± 0.310	50	92	0-8.010
Perennial forbs	0.492 ± 0.156	50	24	0-5.458
Half shrubs	0.190 ± 0.117	50	6	0-5.069
Total	7.418 ± 0.673	50	100	1.865-21.024
PLOT 1-F				
Agropyron smithii	1.181 ± 0.324	50	30	0-9.337
Bromus tectorum	0.008 ± 0.008	50	2	0-0.403
Oryzopsis hymenoides	0.824 ± 0.199	50	36	0-6.504
Other perennial grasses	4.227 ± 0.586	50	88	0-24.151
Perennial forbs	2.261 ± 0.631	50	42	0-25.436
Half shrubs	0.460 ± 0.180	50	16	0-6.387
Total	9.825 ± 1.218	50	92	0-50.285

Table A8.7.2-14. Mean production ± the standard error of the mean (S.E.), frequency, and range of observed values for quadrats in Plots 1-O and 1-F, July 1977. Based on data derived from regression equations. Production values in grams/m^2.

	Mean ± S.E.	Sample Size	Frequency (%)	Range of Values
PLOT 1-O				
Agropyron smithii	0.047 ± 0.033	50	4	0-1.312
Oryzopsis hymenoides	2.057 ± 0.629	50	30	0-17.991
Other perennial grasses	5.902 ± 0.639	50	92	0-15.648
Perennial forbs	0.593 ± 0.274	50	24	0-11.587
Annual forbs	0.005 ± 0.004	50	4	0-0.150
Half shrubs	0.233 ± 0.181	50	8	0-8.943
Total	8.751 ± 0.803	50	98	0-26.197
PLOT 1-F				
Agropyron smithii	0.407 ± 0.161	50	16	0-4.345
Oryzopsis hymenoides	2.084 ± 0.481	50	42	0-17.121
Other perennial grasses	7.623 ± 0.836	50	94	0-24.729
Perennial forbs	1.584 ± 0.639	50	46	0-22.095
Annual forbs	0.002 ± 0.002	50	2	0-0.100
Half shrubs	0.107 ± 0.043	50	12	0-1.145
Total	11.064 ± 0.928	50	98	0-31.807

Table A8.7.2-15 Mean production ± the standard error of the mean (S.E.), frequency, and range of observed values for quadrats in Plots 2-0 and 2-F, May 1977. Based on data derived from regression equations. Production values in grams/m^2.

	Mean ± S.E.	Sample Size	Frequency (%)	Range of Values
PLOT 2-0				
Agropyron smithii	0.548 ± 0.131	50	30	0-3.276
Bromus tectorum	0.497 ± 0.157	50	36	0-6.709
Oryzopsis hymenoides	0.488 ± 0.139	50	22	0-3.666
Other perennial grasses	7.324 ± 1.003	50	80	0-27.885
Perennial forbs	0.398 ± 0.127	50	46	0-4.945
Annual forbs	0.077 ± 0.034	50	16	0-1.460
Half shrubs	0.038 ± 0.038	50	2	0-1.895
Total	9.482 ± 0.888	50	98	0-27.660
PLOT 2-F				
Agropyron smithii	0.843 ± 0.260	50	34	0-10.955
Bromus tectorum	0.702 ± 0.171	50	48	0-5.405
Oryzopsis hymenoides	0.799 ± 0.161	50	36	0-3.666
Other perennial grasses	5.306 ± 0.510	50	94	0-18.649
Perennial forbs	3.043 ± 0.642	50	88	0-27.359
Annual forbs	0.045 ± 0.030	50	12	0-1.460
Half shrubs	0.857 ± 0.540	50	8	0-20.845
Total	12.500 ± 1.215	50	100	1.213-39.033

Table A8.7.2-16 Mean production ± the standard error of the mean (S.E.), frequency, and range of observed values for quadrats in Plots 2-0 and 2-F, June 1977. Based on data derived from regression equations. Production values in grams/m^2.

	Mean ± S.E.	Sample Size	Frequency (%)	Range of Values
PLOT 2-0				
Agropyron smithii	0.684 ± 0.290	50	16	0-12.180
Bromus tectorum	0.016 ± 0.011	50	4	0-0.403
Oryzopsis hymenoides	0.124 ± 0.084	50	6	0-3.745
Other perennial grasses	3.412 ± 0.345	50	86	0-12.853
Perennial forbs	1.291 ± 0.497	50	28	0-16.072
Annual forbs	0.129 ± 0.070	50	10	0-3.039
Half shrubs	0.031 ± 0.031	50	2	0-1.557
Total	7.921 ± 0.849	50	96	0-25.552
PLOT 2-F				
Agropyron smithii	0.793 ± 0.220	50	26	0-5.073
Oryzopsis hymenoides	0.879 ± 0.309	50	22	0-9.263
Other perennial grasses	2.004 ± 0.211	50	76	0-7.365
Perennial forbs	1.365 ± 0.371	50	44	0-12.950
Annual forbs	0.035 ± 0.020	50	6	0-0.585
Half shrubs	0.040 ± 0.040	50	2	0-1.996
Total	5.585 ± 0.551	50	94	0-16.147

Table A8.7.2-17. Mean production ± the standard error of the mean (S.E.), frequency, and range of observed values for quadrats in Plots 2-O and 2-F, July 1977. Based on data derived from regression equations. Production values in grams/m^2.

	Mean ± S.E.	Sample Size	Frequency (%)	Range of Values
PLOT 2-O				
Agropyron smithii	1.024 ± 0.261	50	28	0-5.861
Bromus tectorum	0.009 ± 0.009	50	2	0-0.453
Oryzopsis hymenoides	0.480 ± 0.226	50	12	0-9.291
Other perennial grasses	4.746 ± 0.707	50	72	0-15.648
Perennial forbs	0.685 ± 0.240	50	32	0-9.114
Annual forbs	0.299 ± 0.203	50	20	0-9.957
Half shrubs	0.013 ± 0.013	50	2	0-0.672
Total	7.460 ± 0.832	50	92	0-22.063
PLOT 2-F				
Agropyron smithii	0.372 ± 0.152	50	16	0-5.861
Bromus tectorum	0.014 ± 0.010	50	4	0-0.453
Oryzopsis hymenoides	1.621 ± 0.557	50	24	0-17.991
Other perennial grasses	4.819 ± 0.743	50	78	0-24.729
Perennial forbs	1.152 ± 0.405	50	34	0-13.441
Annual forbs	0.267 ± 0.201	50	12	0-9.957
Half shrubs	0.032 ± 0.032	50	2	0-1.617
Total	8.073 ± 0.942	50	94	0-24.425

Table A8.7.2-18 Mean production ± the standard error of the mean (S.E.), frequency, and range of observed values for quadrats in Plots 3-O and 3-F, May 1977. Based on data derived from regression equations. Production values in grams/m^2.

	Mean ± S.E.	Sample Size	Frequency (%)	Range of Values
PLOT 3-O				
Agropyron smithii	0.898 ± 0.133	50	56	0-3.276
Other perennial grasses	7.576 ± 0.282	50	100	3.980-12.672
Perennial forbs	3.066 ± 0.171	50	100	1.065-5.807
Annual forbs	0.016 ± 0.007	50	10	0-0.158
Total	12.215 ± 0.361	50	100	7.296-17.875
PLOT 3-F				
Agropyron smithii	4.607 ± 0.301	50	100	1.741-9.931
Other perennial grasses	8.913 ± 0.387	50	100	1.807-14.846
Perennial forbs	3.981 ± 0.266	50	100	1.065-9.686
Annual forbs	0.029 ± 0.010	50	16	0-0.344
Half shrubs	0.008 ± 0.008	50	2	0-0.379
Total	18.160 ± 0.615	50	100	9.940-25.809

Table A8.7.2-19. Mean production ± the standard error of the mean (S.E.), frequency, and range of observed values for quadrats in Plots 3-0 and 3-F, June 1977. Based on data derived from regression equations. Production values in grams/m^2.

	Mean ± S.E.	Sample Size	Frequency (%)	Range of Values
PLOT 3-0				
Agropyron smithii	4.263 ± 0.207	50	100	1.875-9.337
Other perennial grasses	2.942 ± 0.115	50	100	1.877-5.428
Perennial forbs	1.457 ± 0.121	50	96	0-4.210
Half shrubs	0.076 ± 0.041	50	8	0-1.557
Total	8.421 ± 0.345	50	100	3.955-14.754
PLOT 3-F				
Agropyron smithii	4.337 ± 0.245	50	96	0-8.626
Other perennial grasses	3.258 ± 0.109	50	100	2.199-6.396
Perennial forbs	1.617 ± 0.162	50	82	0-5.458
Half shrubs	0.164 ± 0.076	50	10	0-2.874
Total	9.633 ± 0.364	50	100	4.304-18.934

Table A8.7.2-20. Mean production ± the standard error of the mean (S.E.), frequency, and range of observed values for quadrats in Plots 3-O and 3-F, July 1977. Based on data derived from regression equations. Production values in grams/m^2.

	Mean ± S.E.	Sample Size	Frequency (%)	Range of Values
PLOT 3-O				
Agropyron smithii	3.011 ± 0.186	50	100	1.060-5.861
Other perennial grasses	4.181 ± 0.183	50	100	2.328-6.566
Perennial forbs	0.622 ± 0.089	50	88	0-2.933
Half shrubs	0.067 ± 0.029	50	10	0-0.909
Total	7.743 ± 0.319	50	100	4.643-14.387
PLOT 3-F				
Agropyron smithii	2.920 ± 0.144	50	100	1.312-5.861
Other perennial grasses	4.011 ± 0.228	50	100	1.723-9.593
Perennial forbs	0.616 ± 0.122	50	80	0-4.170
Half shrubs	0.056 ± 0.028	50	8	0-0.909
Total	7.448 ± 0.267	50	100	4.348-12.025

Table A8.7.2-21. Mean production ± the standard error of the mean (S.E.), frequency, and range of observed values for quadrats in Plots 4-0 and 4-F, May 1977. Based on data derived from regression equations. Production values in grams/m^2.

	Mean	± S.E.	Sample Size	Frequency (%)	Range of Values
PLOT 4-0					
Agropyron smithii	1.242	± 0.170	50	64	0-4.300
Bromus tectorum	0.020	± 0.015	50	4	0-0.620
Oryzopsis hymenoides	0.294	± 0.157	50	10	0-6.921
Other perennial grasses	1.263	± 0.416	50	60	0-8.869
Perennial forbs	0.015	± 0.013	50	4	0-0.634
Annual forbs	0.036	± 0.013	50	16	0-0.344
Total	2.782	± 0.306	50	92	0-9.676
PLOT 4-F					
Agropyron smithii	0.741	± 0.117	50	52	0-2.764
Bromus tectorum	0.008	± 0.008	50	2	0-0.403
Oryzopsis hymenoides	0.726	± 0.188	50	28	0-5.474
Other perennial grasses	0.809	± 0.165	50	46	0-6.153
Other annual grasses	0.021	± 0.021	50	2	0-1.055
Perennial forbs	0.054	± 0.025	50	18	0-1.065
Annual forbs	0.074	± 0.034	50	16	0-1.460
Total	2.541	± 0.225	50	90	0-7.296

Table A8.7.2-22. Mean production ± the standard error of the mean (S.E.), frequency, and range of observed values for quadrats in Plots 4-0 and 4-F, June 1977. Based on data derived from regression equations. Production values in grams/m^2.

	Mean	± S.E.	Sample Size	Frequency (%)	Range of Values
PLOT 4-0					
Agropyron smithii	1.074	± 0.152	50	52	0-2.941
Oryzopsis hymenoides	0.236	± 0.119	50	10	0-4.665
Other perennial grasses	1.015	± 0.197	50	40	0-4.782
Perennial forbs	0.037	± 0.026	50	4	0-1.088
Annual forbs	0.012	± 0.012	50	2	0-0.585
Half shrubs	0.177	± 0.093	50	8	0-3.752
Total	2.849	± 0.324	50	84	0-10.574
PLOT 4-F					
Agropyron smithii	1.205	± 0.136	50	62	0-2.230
Oryzopsis hymenoides	0.652	± 0.179	50	30	0-5.584
Other perennial grasses	0.745	± 0.171	50	34	0-4.782
Perennial forbs	0.081	± 0.042	50	8	0-1.713
Annual forbs	0.030	± 0.022	50	4	0-0.936
Half shrubs	0.396	± 0.117	50	22	0-3.313
Total	3.058	± 0.321	50	84	0-9.180

Table A8.7.2-23 Mean production ± the standard error of the mean (S.E.), frequency, and range of observed values for quadrats in Plots 4-O and 4-F, July 1977. Based on data derived from regression equations. Production values in grams/m^2.

	Mean ± S.E.	Sample Size	Frequency (%)	Range of Values
PLOT 4-O				
Agropyron smithii	1.202 ± 0.246	50	50	0-9.904
Bromus tectorum	0.009 ± 0.009	50	2	0-0.453
Oryzopsis hymenoides	0.593 ± 0.297	50	12	0-11.031
Other perennial grasses	2.070 ± 0.728	50	40	0-32.600
Perennial forbs	0.012 ± 0.010	50	4	0-0.461
Annual forbs	0.006 ± 0.003	50	6	0-0.100
Half shrubs	0.352 ± 0.212	50	8	0-7.525
Total	4.605 ± 0.858	50	82	0-32.102
PLOT 4-F				
Agropyron smithii	0.870 ± 0.167	50	42	0-3.839
Oryzopsis hymenoides	1.175 ± 0.292	50	28	0-6.681
Other perennial grasses	1.363 ± 0.391	50	38	0-13.831
Perennial forbs	0.015 ± 0.010	50	6	0-0.461
Annual forbs	0.007 ± 0.004	50	6	0-0.150
Half shrubs	0.594 ± 0.241	50	18	0-9.888
Total	4.483 ± 0.709	50	86	0-27.968

Table A8.7.2-24. Mean production ± the standard error of the mean (S.E.), frequency, and range of observed values for quadrats in Plots 5-0 and 5-F, May 1977. Based on data derived from regression equations. Production values in grams/m^2.

	Mean ± S.E.	Sample Size	Frequency (%)	Range of Values
PLOT 5-0				
Agropyron smithii	0.025 ± 0.025	50	2	0-1.229
Oryzopsis hymenoides	1.882 ± 0.336	50	62	0-13.794
Other perennial grasses	2.201 ± 0.439	50	40	0-18.649
Other annual grasses	0.039 ± 0.038	50	2	0-1.925
Perennial forbs	0.529 ± 0.367	50	12	0-17.014
Total	5.071 ± 1.038	50	98	0-43.264
PLOT 5-F				
Agropyron smithii	0.697 ± 0.174	50	38	0-5.836
Oryzopsis hymenoides	1.613 ± 0.240	50	58	0-5.474
Other perennial grasses	3.211 ± 0.383	50	80	0-11.586
Perennial forbs	0.599 ± 0.135	50	50	0-4.083
Annual forbs	0.010 ± 0.008	50	4	0-0.344
Total	6.238 ± 0.508	50	100	1.213-16.817

Table A8.7.2-25 Mean production ± the standard error of the mean (S.E.), frequency, and range of observed values for quadrats in Plots 5-O and 5-F, June 1977. Based on data derived from regression equations. Production values in grams/m^2.

	Mean ± S.E.	Sample Size	Frequency (%)	Range of Values
PLOT 5-O				
Agropyron smithii	0.232 ± 0.090	50	12	0-2.230
Oryzopsis hymenoides	2.404 ± 0.417	50	62	0-11.103
Other perennial grasses	0.728 ± 0.151	50	34	0-3.491
Perennial forbs	0.031 ± 0.022	50	4	0-0.776
Annual forbs	0.012 ± 0.012	50	2	0-0.585
Total	3.573 ± 0.365	50	84	0-9.877
PLOT 5-F				
Agropyron smithii	0.941 ± 0.221	50	32	0-6.494
Oryzopsis hymenoides	1.839 ± 0.310	50	70	0-7.424
Other perennial grasses	1.911 ± 0.212	50	70	0-4.782
Perennial forbs	0.330 ± 0.109	50	20	0-3.586
Annual forbs	0.012 ± 0.012	50	2	0-0.585
Half shrubs	0.093 ± 0.054	50	6	0-1.996
Total	5.474 ± 0.453	50	100	1.865-19.631

Table A8.7.2-26. Mean production ± the standard error of the mean (S.E.), frequency, and range of observed values for quadrats in Plots 5-O and 5-F, July 1977. Based on data derived from regression equations. Production values in grams/m^2.

	Mean ± S.E.	Sample Size	Frequency (%)	Range of Values
PLOT 5-O				
Agropyron smithii	0.748 ± 0.316	50	22	0-13.441
Oryzopsis hymenoides	2.098 ± 0.414	50	62	0-13.641
Other perennial grasses	2.460 ± 0.668	50	56	0-22.913
Perennial forbs	0.080 ± 0.041	50	16	0-1.697
Total	4.902 ± 0.854	50	94	0-28.559
PLOT 5-F				
Agropyron smithii	0.440 ± 0.094	50	32	0-1.818
Oryzopsis hymenoides	2.115 ± 0.482	50	56	0-15.381
Other perennial grasses	3.161 ± 0.430	50	84	0-18.520
Perennial forbs	0.268 ± 0.134	50	18	0-6.024
Annual forbs	0.002 ± 0.002	50	2	0-0.100
Half shrubs	0.983 ± 0.052	50	18	0-1.697
Total	5.029 ± 0.539	50	90	0-18.520

Table A8.7.2-27. Mean production ± the standard error of the mean (S.E.), frequency, and range of observed values for quadrats in Plots 6-O and 6-F, May 1977. Based on data derived from regression equations. Production values in grams/m^2.

	Mean ± S.E.	Sample Size	Frequency (%)	Range of Values
PLOT 6-O				
Agropyron smithii	1.238 ± 0.582	50	42	0-28.631
Oryzopsis hymenoides	0.052 ± 0.052	50	2	0-2.581
Other perennial grasses	6.224 ± 0.600	50	88	0-17.019
Perennial forbs	2.012 ± 0.469	50	70	0-14.859
Total	9.965 ± 1.039	50	92	0-32.685
PLOT 6-F				
Agropyron smithii	0.191 ± 0.059	50	18	0-1.229
Oryzopsis hymenoides	0.400 ± 0.120	50	20	0-3.304
Other perennial grasses	3.440 ± 0.314	50	96	0-11.586
Perennial forbs	0.544 ± 0.240	50	48	0-10.548
Total	4.695 ± 0.414	50	98	0-15.494

Table A8.7.2-28. Mean production ± the standard error of the mean (S.E.), frequency, and range of observed values for quadrats in Plots 6-O and 6-F, June 1977. Based on data derived from regression equations. Production values in grams/m^2.

	Mean ± S.E.	Sample Size	Frequency (%)	Range of Values
PLOT 6-O				
Agropyron smithii	0.546 ± 0.180	50	20	0-5.783
Oryzopsis hymenoides	0.030 ± 0.022	50	4	0-0.985
Other perennial grasses	3.456 ± 0.337	50	88	0-11.238
Perennial forbs	1.471 ± 0.423	50	44	0-12.950
Total	7.531 ± 0.896	50	90	0-30.778
PLOT 6-F				
Agropyron smithii	0.418 ± 0.124	50	20	0-3.651
Oryzopsis hymenoides	0.498 ± 0.144	50	30	0-4.664
Other perennial grasses	2.259 ± 0.125	50	92	0-4.136
Perennial forbs	0.270 ± 0.085	50	26	0-3.586
Total	3.857 ± 0.266	50	94	0-7.787

Table A8.7.2-29. Mean production ± the standard error of the mean (S.E.), frequency, and range of observed values for quadrats in Plots 6-0 and 6-F, July 1977. Based on data derived from regression equations. Production values in grams/m^2.

	Mean ± S.E.	Sample Size	Frequency (%)	Range of Values
PLOT 6-0				
Agropyron smithii	0.677 ± 0.438	50	10	0-21.022
Other perennial grasses	6.305 ± 1.375	50	94	0-67.109
Perennial forbs	1.497 ± 0.381	50	62	0-12.205
Total	8.686 ± 1.609	50	96	0-75.209
PLOT 6-F				
Agropyron smithii	0.093 ± 0.071	50	4	0-3.334
Oryzopsis hymenoides	1.586 ± 0.407	50	46	0-15.381
Other perennial grasses	4.307 ± 0.403	50	94	0-12.015
Perennial forbs	0.886 ± 0.254	50	46	0-8.496
Annual forbs	0.003 ± 0.003	50	2	0-0.150
Half shrubs	0.016 ± 0.014	50	4	0-0.672
Total	6.430 ± 0.546	50	96	0-16.158

Table A8.7.2-30. Fresh weight estimates (grams) for intensive study plot 1-F, chained pinyon-juniper rangeland. July, 1978.

Quadrat Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Agropyron smithii		<1			<1												18						6		11
	1																						<1		
Bromus tectorum		1					<1						<1			<1			<1						
					1		<1				<1		<1		<1			<1		<1					1
Oryzopsis hymenoides		35	17	27			10	17	10	30	12		30	7				45	50	65	13		80		
		6			40	2	100	12	65	10		33		65	55		50	5		40	<1		40	7	25
Perennial grasses	20	3		11	12	35	20	12		3	13	8	6	37	28	30		5		45	83	2	4		
		55	12	40	3	35	13	15	5	3	1	40	10	5	40	55	85	13	18	5	15	10		10	20
Perennial forbs					3	40						5		2		<1	3								
									1				1		2		2			10					40
Annual forbs					<1		<1					<1					1			2					<1
					<1																				1
Half shrubs											45						30						35		
					7		5						3				4	18		8			3		3
Total Biomass	20	39	17	38	15	75	30	29	10	33	70	13	36	46	28	30	52	50	50	112	96	2	125	0	11
	1	61	12	40	51	37	118	27	71	13	1	73	14	70	97	55	141	36	18	63	15	10	40	17	90

Table A8.7.2.31 . Fresh weight estimates (grams) for intensive study plot 2-F, chained pinyon-juniper rangeland. July, 1978

Quadrat Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
<u>Agropyron smithii</u>	13	2	14	5	20	23	2	1	25	18		1			18		25		6	11		26	80	20	5
	6		40	19			20	33								27								40	
<u>Bromus tectorum</u>	<1	1	3	<1	<1	3	<1	<1	1	<1	4	2					1	1	1		2	1	3		
	<1				5	<1	3		4	9	5	1	<1	6	4	3	6	<1	2		1	3	5		7
<u>Oryzopsis hymenoides</u>		17					33										4	3	8						
	16								33			8					35	55		7			10	30	
Perennial grasses	30	35		55		2		70	15		6	1	27	60		45	6	2	3		35			17	52
		2	25	30	7		30	12	5			18		1				5	20	2		70			6
Perennial forbs			18				4	2	1	20					16		37		1		2				4
		1	2							2								2						2	
Annual forbs			<1			1			<1		4	<1			1					<1	2	1			
	1									2	7	2			1	1	2		2			1			
Half shrubs					3				11												4				
																12									
Total Biomass	43	55	35	60	23	29	39	73	53	38	14	4	27	60	35	45	73	6	19	11	45	28	83	37	61
	23	3	67	49	12	<1	53	45	42	13	12	29	<1	7	5	43	43	62	24	9	1	74	15	72	13

Table A8.7.2-32 . Fresh weight estimates (grams) for intensive study plot 5-F, pinyon-juniper woodland. July 1978.

Quadrat Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Agropyron smithii		2	5	<1			2	2												2		1		3	
																	3					8	3	2	
Bromus tectorum																							<1		
		2							<1					1		<1					<1			<1	
Oryzopsis hymenoides	35		13	10			5	7					<1	4	3			5		2		2	20	16	1
	1	2	4	18			50			15			7				6			13	5			18	
Perennial grasses	20	<1	8	<1	25	22		20	8	5	15	3	1	6		18	8				10	5	2	40	15
	5	3	8		9	15	4	35	11	8	13	25	19	20	3	6	7	80	40	1		12	32	50	200
Perennial forbs					2								2											4	
				1	3		6		3			<1							17	<1	2	<1	2	8	
Annual forbs	<1	<1	<1		<1		<1		<1			<1								<1	4				
			<1	<1	<1	3			<1		<1	1	<1	1		1					2	<1	1		
Half shrubs																							1		
				1																					
Total Biomass	55	2	26	10	27	22	7	29	8	5	15	3	3	10	3	18	8	5	0	4	14	8	23	63	16
	6	7	12	20	12	18	60	35	14	23	13	26	26	22	3	7	16	80	57	14	9	20	38	78	200

Table A.8.7.2-33. Fresh weight estimates (grams) for intensive study plot 6-F, pinyon-juniper woodland. July, 1978.

Quadrat	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Number	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
<u>Agropyron</u>						3	4	3	<1			2	9		6	1	4		1				9		
<u>smithii</u>		3			12			3	15	6	20	10	3	35			20		5	40	9	3	45		
<u>Bromus</u>																									
<u>tectorum</u>					2									<1	4										
<u>Oryzopsis</u>				30												65		35		15	47	40			10
<u>hymenoides</u>				12	30	6				13			2	3	45					12		2	50		
Perennial	70	55	20	95	100	30	60	50	20		<1	13	10	40	28	45	60	100	7	100	110	40	45	65	45
grasses	50	20	150	55	60	85	110	50	120	85	17	30	85	35	5	50	55	35	30	100	30	40	45	60	14
Perennial	2	15			4	3	3	45	15			7	1	14	30	35	22	10	12	20	22	60	25	50	30
forbs	15	30	20	55	25	18	2	32	7	35	18	7	6		6	15	6	33	30	1	6	12		20	15
Annual										11														1	
forbs								<1					<1											<1	
Half		60							10			7													
shrubs																									
Total	72	130	20	125	104	36	67	98	45	11	<1	29	20	54	64	146	86	145	20	135	179	140	79	116	85
Biomass	65	53	170	122	129	109	112	85	142	139	55	47	96	43	60	65	81	68	65	153	45	57	140	80	29

Table A8.7.2-34. Oven dry weights (grams) for chained pinyon-juniper rangeland plots 1-F and 2-F. 1978.

	Quadrat Number	*Agropyron smithii*	*Bromus tectorum*	*Oryzopsis hymenoides*	Other Perennial Grasses	Perennial Forbs	Annual Forbs	Half Shrubs	Total Biomass
Plot 1-F	2		3.820	38.283	9.301	0.037			51.404
	5				9.597		0.547		10.144
	10			21.505	1.071				22.576
	16		0.336		29.040	0.149	0.158		29.525
	20			38.994	40.052		2.356		81.402
	21			6.114	64.422				70.536
	30		3.929	23.056	3.846		1.229	4.361	36.421
	32		0.115	62.142	10.861			2.301	75.419
	39		0.312	37.307	2.619				39.926
	40		0.787	22.570	37.541	1.435			62.333
Plot 2-F	6	25.321	3.755		1.096		0.064		30.236
	12		3.398		1.531		0.143		5.072
	15	33.175	0.120			9.202	0.914		43.291
	16		0.095		51.016	0.172			51.188
	21		4.143		17.633		2.010	1.642	25.428
	28	17.526			18.794	0.542			36.862
	34		7.982	15.106	5.685		0.237		29.010
	35		29.132			0.228	2.515		31.875
	36		7.970				3.859		11.829
	48		7.509	5.396					12.905

Table A8.7.2-35. Oven dry weights (grams) for pinyon-juniper woodland plots 5-F and 6-F. 1978.

	Quadrat Number	*Agropyron smithii*	*Bromus tectorum*	*Oryzopsis hymenoides*	Other Perennial Grasses	Perennial Forbs	Annual Forbs	Half Shrubs	Total Biomass
Plot 5-F	7	1.573		4.089	0.372		0.179		5.841
	9				3.776				3.776
	12				1.199		0.157		1.356
	14			1.787	3.859				5.646
	31				3.819		1.073		4.892
	35			10.729	3.109				13.838
	41		0.087		2.144		0.152		2.383
	44				20.260	4.358			24.618
	46		0.242	3.941		0.173	0.702		5.058
	48				21.615	1.776	0.471		23.862
Plot 6-F	6	0.396			7.489	1.210			9.095
	13	1.989			5.911	0.148			8.048
	21	4.441		24.508	55.049	15.879	0.025		95.461
	28	4.903			56.719	5.568			62.287
	33	3.570			27.376	14.751	0.875		46.572
	38	3.194			67.699	1.755			72.648
	43	1.344			22.264	26.876	0.199		49.140
	47	3.374	0.020	0.373	22.784	8.857			35.388
	49				28.806	11.719	0.415		40.940
	50				5.448	7.123			12.571

Table A8.7.2-36. Regression equations used for converting fresh weight estimates to oven dry weights in plots 1-F, 2-F, 5-F, and 6-F. 1978.

Species / Species Group	Regression Equation	Correlation Coefficient
Agropyron smithii	$y = 0.650x + 2.503$	0.70
Bromus tectorum	$y = 2.748x - 1.543$	0.93
Oryzopsis hymenoides	$y = 0.586x + 0.565$	0.95
Other perennial grasses	$y = 0.520x + 3.415$	0.88
Perennial forbs	$y = 0.616x - 0.893$	0.91
Annual forbs	$y = 0.537x + 0.234$	0.81
Half shrubs	$y = 0.924x - 2.160$	0.99
Total Biomass	$y = 0.518x + 6.597$	0.89

Table A8.7.2-37. Mean production ± the standard error of the mean (S.E.), frequency, and range of observed values for quadrats at chained pinyon-juniper rangeland Plots 1-F and 2-F, 1978. Production data are in grams/m^2 based on data derived from regression equations.

	Mean	±	S.E.	Sample Size	Frequency (%)	Range of Values
PLOT 1-F						
Agropyron smithii	0.838	±	0.370	50	14	0-14.201
Bromus tectorum	0.092	±	0.041	50	26	0-1.205
Oryzopsis hymenoides	12.115	±	2.098	50	64	0-59.125
Other perennial grasses	12.077	±	1.579	50	84	0-47.636
Perennial forbs	1.164	±	0.668	50	24	0-23.747
Annual forbs	0.107	±	0.038	50	16	0-1.307
Half shrubs	2.500	±	1.119	50	22	0-39.420
Total	29.461	±	2.542	50	100	6.597-79.635
PLOT 2-F						
Agropyron smithii	7.800	±	1.539	50	52	0-54.495
Bromus tectorum	3.968	±	0.796	50	74	0-23.189
Oryzopsis hymenoides	3.180	±	1.005	50	26	0-32.733
Other perennial grasses	9.338	±	1.615	50	62	0-39.832
Perennial forbs	1.161	±	0.547	50	32	0-21.900
Annual forbs	0.411	±	0.105	50	38	0-3.992
Half shrubs	0.382	±	0.238	50	8	0-8.928
Total	24.406	±	1.707	50	100	6.856-49.591

Table A8.7.2-38. Mean production ± the standard error of the mean (S.E.), frequency, and range of observed values for quadrats at pinyon-juniper woodland Plots 5-F and 6-F, 1978. Production data are in grams/m^2 based on data derived from regression equations.

	Mean ± S.E.	Sample Size	Frequency (%)	Range of Values
PLOT 5-F				
Agropyron smithii	1.036 ± 0.277	50	24	0-7.702
Bromus tectorum	0.113 ± 0.082	50	14	0-3.953
Oryzopsis hymenoides	3.357 ± 0.823	50	50	0-29.846
Other perennial grasses	11.724 ± 2.287	50	88	0-107.464
Perennial forbs	0.433 ± 0.213	50	28	0-9.579
Annual forbs	0.323 ± 0.062	50	44	0-2.381
Half shrubs	0.004 ± 0.003	50	4	0-0.100
Total	19.169 ± 2.332	50	100	6.597-110.197
PLOT 6-F				
Agropyron smithii	4.721 ± 1.031	50	58	0-31.750
Bromus tectorum	0.272 ± 0.203	50	8	0-9.449
Oryzopsis hymenoides	5.076 ± 1.374	50	34	0-38.630
Other perennial grasses	30.654 ± 2.556	50	98	0-81.452
Perennial forbs	9.566 ± 1.307	50	88	0-36.068
Annual forbs	0.183 ± 0.124	50	14	0-6.139
Half shrubs	1.293 ± 1.074	50	6	0-53.280
Total	50.306 ± 3.303	50	100	6.856-99.319

Table A8.7.2-39. Oven dry weights (grams) for range cages and adjacent open areas in the pinyon-juniper woodland treatment (development) site north of Piceance Creek. 1978.

	Quadrat Number	*Agropyron smithii*	*Bromus tectorum*	*Oryzopsis hymenoides*	Other Perennial Grasses	Perennial Forbs	Annual Forbs	Half Shrubs	Total Biomass
OPEN AREA	1		0.366	4.515	3.098	0.133	0.069		8.181
	2			1.806				1.403	3.209
	3			2.571	8.848		0.465		11.884
	4	0.378		3.391	4.084		0.660		8.513
	5		0.048	1.558		0.049	0.077	2.921	4.653
	6			0.648	3.891		0.098		4.637
	7				12.104	0.729	0.567		13.400
	8	2.138			1.375	0.048	0.016		3.577
	9		8.606	4.672	6.279	0.169	5.644		25.370
	10		0.071	4.198	9.465	1.341	0.050		15.125
RANGE CAGES	1			1.649	19.731	0.763			22.143
	2			1.590	28.659	2.967	0.012	0.691	33.919
	3		0.018	1.745	6.834		0.557		9.154
	4	0.424	2.971	7.971	35.753	0.388	2.859		50.366
	5			3.365			0.052	1.278	4.695
	6	2.337			1.036				3.373
	7		0.907	18.739	12.863	0.049	1.165	0.474	34.197
	8	0.488		12.971			0.015		13.474
	9		3.731	6.907	3.853		1.646		16.137
	10		0.017	9.379					9.396

Table A8.7.2-40 . Oven dry weights (grams) for range cages and adjacent open areas in the pinyon-juniper woodland control site north of Piceance Creek. 1978.

	Quadrat Number	*Agropyron smithii*	*Bromus tectorum*	*Oryzopsis hymenoides*	Other Perennial Grasses	Perennial Forbs	Annual Forbs	Half Shrubs	Total Biomass
OPEN AREA	1			5.648		0.049			5.697
	2			10.816			0.024		10.840
	3	3.339		2.964	1.347	0.447		3.769	11.866
	4		0.041		4.271	0.159		0.983	5.454
	5			0.430		0.042		0.492	0.964
	6			5.057	5.309	2.077		1.073	13.516
	7		0.037	2.436		0.920			3.393
	8			3.796					3.796
	9			0.011	0.168		3.395		3.574
	10				6.749				6.749
RANGE CAGES	1		0.791	13.983	4.815		0.078		19.667
	2			24.159		0.014			24.173
	3	0.084		5.207	8.961	0.306		0.417	14.975
	4			0.563	9.198	6.506		5.739	22.006
	5				22.659	5.137		0.148	27.946
	6			1.488	9.459	0.497		1.359	12.803
	7			8.416		0.370	0.142		8.928
	8			9.730				1.565	11.295
	9			3.633	1.943		0.003	0.248	5.827
	10			2.915	25.130	1.809		0.024	29.878

Table A8.7.2-41. Mean production ± the standard error of the mean (S.E.), frequency, and range of observed values for clipped plots in the pinyon-juniper woodland development (treatment) site north of Piceance Creek. Production values in grams/m^2. 1978.

	Mean ± S.E.	Sample Size	Frequency (%)	Range of Values
RANGE CAGES				
Agropyron smithii	0.325 ± 0.232	10	30	0-2.337
Bromus tectorum	0.764 ± 0.444	10	50	0-3.731
Oryzopsis hymenoides	6.433 ± 1.899	10	90	0-18.739
Other perennial grasses	10.873 ± 4.130	10	70	0-35.753
Perennial forbs	0.417 ± 0.294	10	40	0-2.967
Annual forbs	0.631 ± 0.309	10	70	0-2.859
Half shrubs	0.244 ± 0.139	10	30	0-1.278
Total	19.685 ± 4.853	10	100	3.373-50.366
OPEN AREAS				
Agropyron smithii	0.252 ± 0.213	10	20	0-2.138
Bromus tectorum	0.909 ± 0.856	10	40	0-8.606
Oryzopsis hymenoides	2.336 ± 0.572	10	80	0-4.672
Other perennial grasses	4.914 ± 1.315	10	80	0-12.104
Perennial forbs	0.247 ± 0.140	10	60	0-1.341
Annual forbs	0.765 ± 0.548	10	90	0-5.644
Half shrubs	0.432 ± 0.310	10	20	0-2.921
Total	9.855 ± 2.180	10	100	3.209-25.370

Table A8.7.2-42. Mean production ± the standard error of the mean (S.E.), frequency, and range of observed values for clipped plots in the pinyon-juniper woodland control site north of Piceance Creek. Production values in grams/m^2. 1978.

	Mean ± S.E.	Sample Size	Frequency (%)	Range of Values
RANGE CAGES				
Agropyron smithii	0.008 ± 0.008	10	10	0-0.084
Bromus tectorum	0.079 ± 0.079	10	10	0-0.791
Oryzopsis hymenoides	7.009 ± 2.368	10	90	0-24.159
Other perennial grass	8.216 ± 2.889	10	70	0-25.130
Perennial forbs	1.464 ± 0.753	10	70	0-6.506
Annual forbs	0.022 ± 0.015	10	30	0-0.142
Half shrubs	0.950 ± 0.562	10	70	0-5.739
Total	17.750 ± 2.599	10	100	5.827-29.878
OPEN AREAS				
Agropyron smithii	0.334 ± 0.334	10	10	0-3.339
Bromus tectorum	0.008 ± 0.005	10	20	0-0.041
Oryzopsis hymenoides	3.116 ± 1.089	10	80	0-10.816
Other perennial grasses	1.784 ± 0.830	10	50	0-6.749
Perennial forbs	0.369 ± 0.211	10	60	0-2.077
Annual forbs	0.342 ± 0.339	10	20	0-3.395
Half shrubs	0.632 ± 0.374	10	40	0-3.769
Total	6.585 ± 1.311	10	100	0.964-13.516

Table A8.7.3-1

Production and utilization of bitterbrush in the chained rangeland habitat, 1977-78.

Transect	A PRODUCTION: length of new shoots in fall(mm) Mean ± SE (N)	B Length of shoots remaining in spring(mm) Mean ± SE (N)	C UTILIZATION: in percent $C=\frac{A-B}{A} \times 100$
BA 17 (CH-C-1)	42 ± 3.8 (100)	3 ± 0.6 (90)	92
BA 18 (CH-C-2)	75 ± 9.0 (100)	4 ± 0.9 (100)	94
BA 25 (CH-C-3)	73 ± 8.3 (100)	5 ± 0.8 (100)	94
Combined	63 ± 4.3 (300)	4 ± 0.5 (290)	93
BA 21 (CH-T-1)	73 ± 6.4 (100)	9 ± 1.1 (100)	88
BA 20 (CH-T-2)	145 ± 11.2 (100)	10 ± 1.5 (100)	93
BA 23 (CH-T-3)	143 ± 10.6. (100)	16 ± 2.3 (100)	89
Combined	120 ± 5.9 (300)	12 ± 1.0 (300)	90

Table A8.7.3-2

Production and utilization of bitterbrush in the pinyon-juniper habitat, 1977-78.

Transcept	A PRODUCTION: length of new shoots in fall (mm) Mean ± SE (N)	B Length of shoots remaining in spring (mm) Mean ± SE (N)	C UTILIZATION: in percent $C=\frac{A-B}{A}\times 100$
BA 19 (PJ-C-1)	48 ± 3.9 (100)	9 ± 2.1 (100)	81
BA 26 (PJ-C-2)	43 ± 3.9 (100)	4 ± 0.9 (100)	91
BA 27 (PJ-C-3)	29 ± 3.1 (100)	4 ± 1.0 (100)	85
Combined	40 ± 2.2 (300)	6 ± 0.8 (300)	85
BA 16 (PJ-T-1)	28 ± 2.6 (99)	5 ± 0.8 (80)	82
BA 22 (PJ-T-2)	94 ± 7.1 (100)	15 ± 1.8 (100)	84
BA 24 (PJ-T-3)	36 ± 2.4 (100)	9 ± 1.5 (90)	75
Combined	53 ± 3.2 (299)	10 ± 0.9 (270)	81

Table A8.7.3-3

Production and utilization of mountain mahogany in the chained rangeland habitat, 1977-78.

Transect	A PRODUCTION: length of new shoots in fall(mm) Mean ± SE (N)	B Length of shoots remaining in spring(mm) Mean ± SE (N)	C UTILIZATION: in percent $C = \frac{A-B}{A} \times 100$
BA 17 (CH-C-1)	5 ± 0.4 (100)	0.5 ± 0.13 (100)	91
BA 18 (CH-C-2)	16 ± 4.2 (100)	3.5 ± 1.23 (100)	79
BA 25 (CH-C-3)	13 ± 1.5 (50)	1.4 ± 0.38 (50)	89
Combined	11 ± 1.7 (250)	1.8 ± 0.51 (250)	83
BA 21 (CH-T-1)	9 ± 1.0 (100)	0.7 ± 0.28 (80)	92
BA 20 (CH-T-2)	15 ± 2.7 (100)	0.9 ± 0.21 (100)	94
BA 23 (CH-T-3)	44 ± 6.6 (98)	4.5 ± 0.80 (100)	90
Combined	23 ± 2.5 (298)	2.1 ± 0.32 (280)	91

Table A8.7.3-4

Production and utilization of mountain mahogany in the pinyon-juniper habitat, 1977-78.

Transect	A PROCUCTION: length of new shoots in fall (mm) Mean ± SE (N)	B Length of shoots remaining in spring (mm) Mean ± SE (N)	C UTILIZATION: in percent $C = \frac{A-B}{A} \times 100$
BA 19 (PJ-C-1)	4 ± 0.2 (100)	1.0 ± 0.18 (100)	72
BA 26 (PJ-C-2)	8 ± 1.1 (100)	1.4 ± 0.38 (100)	82
BA 27 (PJ-C-3)	12 ± 2.2 (100)	2.5 ± 0.90 (100)	80
Combined	8 ± 0.8 (300)	1.6 ± 0.33 (300)	79
BA 16 (PJ-T-1)	2 ± 0.3 (20)	1.5 ± 0.58 (20)	37
BA 22 (PJ-T-2)	23 ± 4.7 (40)	4.6 ± 1.82 (30)	80
BA 24 (PJ-T-3)	19 ± 2.2 (99)	4.6 ± 1.05 (100)	76
Combined	18 ± 1.9 (159)	4.2 ± 0.79 (150)	77

Table A8.7.3-5

Production of bitterbrush, 1978.

Transect	Habitat	PRODUCTION: length of new shoots in fall (mm) Mean ± SE (N)
BA 18	chained rangeland	266 ± 16.6 (100)
BA 25	"	174 ± 11.7 (100)
BA 21	"	211 ± 17.2 (100)
BA 20	"	246 ± 18.8 (100)
BA 23	"	274 ± 25.4 (100)
BA 19	pinyon-juniper	123 ± 7.7 (100)
BA 26	"	133 ± 8.3 (100)
BA 27	"	154 ± 8.7 (100)
BA 16	"	149 ± 9.8 (100)
BA 22	"	179 ± 14.2 (100)
BA 24	"	120 ± 8.2 (100)

Table A8.7.3-6

Baseline evaluation of bitterbrush on Big Jimmy ridge. Twenty 0.04 acre plots occurred along each transect.

Transect	Density: No. of shrubs per acre	No. of shrubs counted	Height class (cm)			Percent live tissue on individual shrubs					No. of seedlings encountered in twenty 0.003 acre plots
			<15	15-40	>40	<25	25	50	75	100	
BA 01	49	39	3	30	6	0	3	16	19	1	0
BA 02	61	49	7	36	6	2	5	24	15	3	1
BA 03	30	24	1	13	10	1	0	6	10	7	0
BA 04	144	115	24	54	37	16	22	34	34	9	0
BA 05	114	91	10	45	36	0	20	45	22	4	0
BA 06	113	90	2	35	53	3	5	33	42	7	0
BA 07	29	23	0	7	16	0	0	4	13	6	0
BA 08	34	27	2	8	17	0	0	6	14	7	0
BA 09	6	5	0	2	3	0	0	2	3	0	0

Table A8.7.3-7

Baseline evaluation of mountain mahogany on Big Jimmy ridge. Twenty 0.04 acre plots occurred along each transect.

Transect	Density: No. of shrubs per acre
BA 01	56
BA 02	0
BA 03	3
BA 04	29
BA 05	3
BA 06	0
BA 07	9
BA 08	0
BA 09	3

Table A8.7.3-8

Sagebrush Ocular Estimates - Fall 1978

Sagebrush Habitat

Transect	Paces	Sample Size	Young	Mature	Decadent	Low	Medium	High	Density
BA01	2	50	10	40	---		48	2	
BA02	2	50	12	38	---	34	16	---	
BA03	2	50	11	39	---	40	10	---	
BA04	3	50	1	48	1	22	24	4	5, 3, 3, 4, 4
BA05	3	50	1	41	8	10	21	19	7, 9, 11, 5, 9
BA06	3	50	2	47	1	21	10	19	9, 9, 6, 4, 14
BA07	3	50	1	47	2	32	13	5	10, 8, 12, 8, 5
BA08	3	50	3	39	8	12	20	18	9, 3, 4, 11, 7
BA09	2	50	1	37	12	7	8	35	7, 6, 2, 11, 6
BA17	2	50	1	49	---	41	9	---	3, 2, 1, 4, 7
BA18	3	50	8	42	---	27	23	---	1, 2, 1, 3, 1
BA20	3	50	1	47	2	15	20	15	5, 2, 3, 7, 3
BA21	3	50	2	47	1	17	27	6	2, 1, 3, 1, 2
BA23	3	50	--	50	---	25	22	3	2, 3, 7, 6, 4
BA25	2	50	--	49	1	11	24	15	4, 9, 7, 1, 1
TOTAL		750	54	660	36	314	295	141	
PERCENT			7.2	88	4.8	41.9	39.3	18.8	

Pinyon Juniper Habitat

Transect	Paces	Sample Size	Young	Mature	Decadent	Low	Medium	High	Density
BA10	5	25	--	15	10	2	10	13	1, 1, 1
BA11	5	25	--	17	8	---	19	6	1, 1, 1
BA12	3	40	--	22	18	5	20	15	1, 2, 1, 1
BA13	3	50	--	30	20	7	20	23	4, 3, 6, 2, 1
BA14	3	50	--	37	13	3	25	22	3, 4, 4, 1, 1
BA15	3	50	--	31	19	3	22	25	1, 5, 5, 1, 3
BA16	3	50	--	20	30	---	13	37	4, 3, 4, 1, 2
BA19	5	25	--	3	22	1	10	14	1, 2, 1
BA22	5	25	--	4	21	1	9	15	2, 1
BA24	5	25	--	2	23	2	3	20	0, 1
BA26	3	50	--	20	30	1	17	32	1, 2, 1, 1, 0
BA27	3	50	--	25	25	2	20	28	1, 1, 2, 1, 1
TOTAL		465	0	226	239	27	188	250	
PERCENT				48.6	51.4	5.8	40.4	53.8	

Table A8.7.3-9

Production of bitterbrush and mountain mahogany treated with fertilizer, 1978. All transects are located in the chained rangeland habitat.

Transect	PRODUCTION: length of new shoots in fall (mm) Mean ± SE (N)	Treatment
Bitterbrush:		
BA 28	185 ± 16 (99)	ammonia nitrate
BA 31	260 ± 20 (100)	ammonia nitrate
BA 17	223 ± 21 (100)	nitrogen and phosphorus
BA 30	201 ± 17 (100)	nitrogen and phosphorus
Mountain mahogany:		
BA 28	132 ± 7 (100)	ammonia nitrate
BA 17	114 ± 7 (100)	nitrogen and phosphorus

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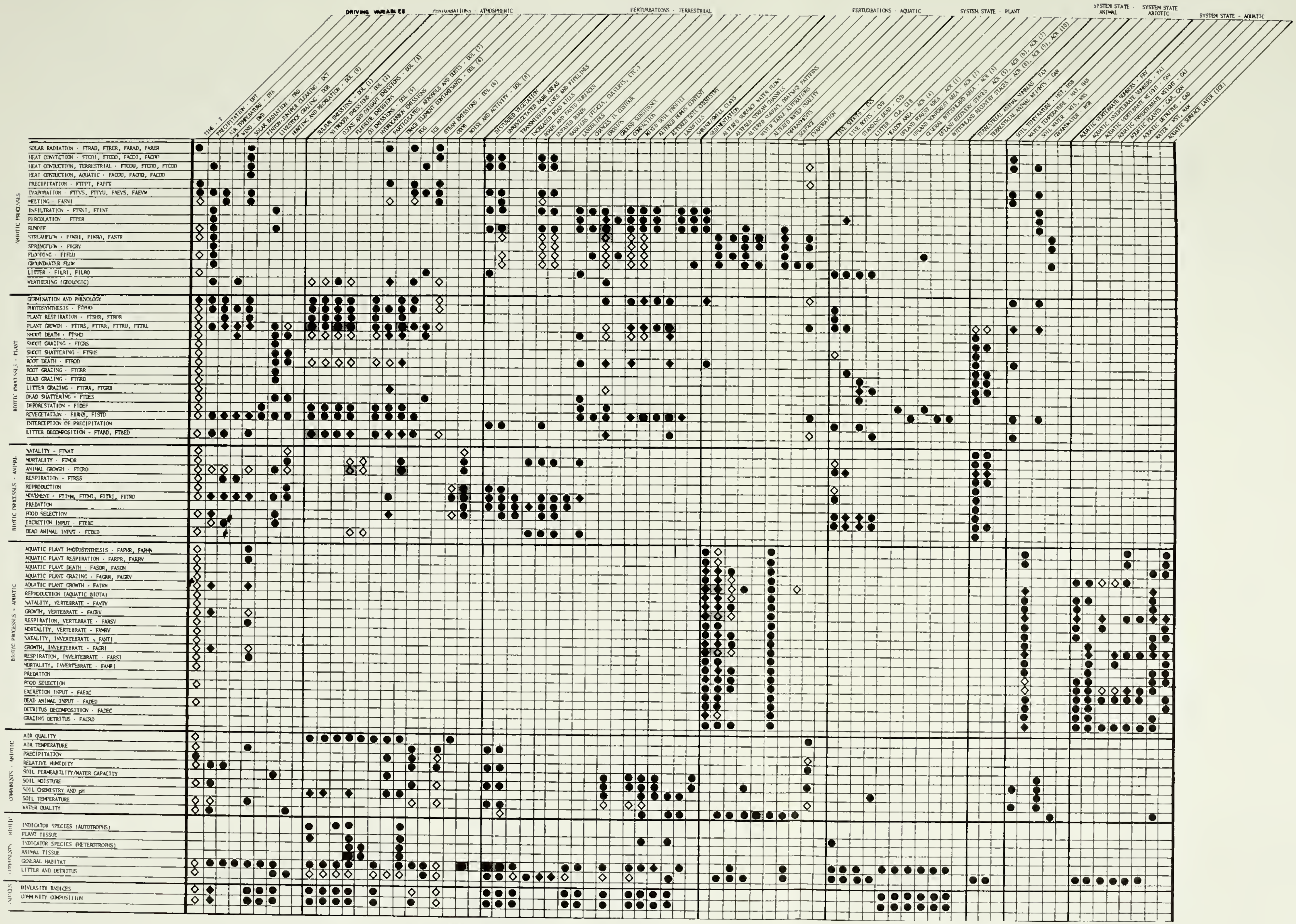

EFFECTS MATRIX. EFFECT GENERATORS ARE LISTED ACROSS TOP, AND EFFECT RECEPTORS ARE LISTED DOWN THE SIDE.

● DIRECT EFFECT

◇ INDIRECT EFFECT

◆ BOTH DIRECT AND INDIRECT EFFECTS

▨ EFFECT OF PARTICULAR CONCERN

FIGURE A12.1-1

Figure A12.3.2-1 PLOT OF DEER KILL AND DEER COUNT

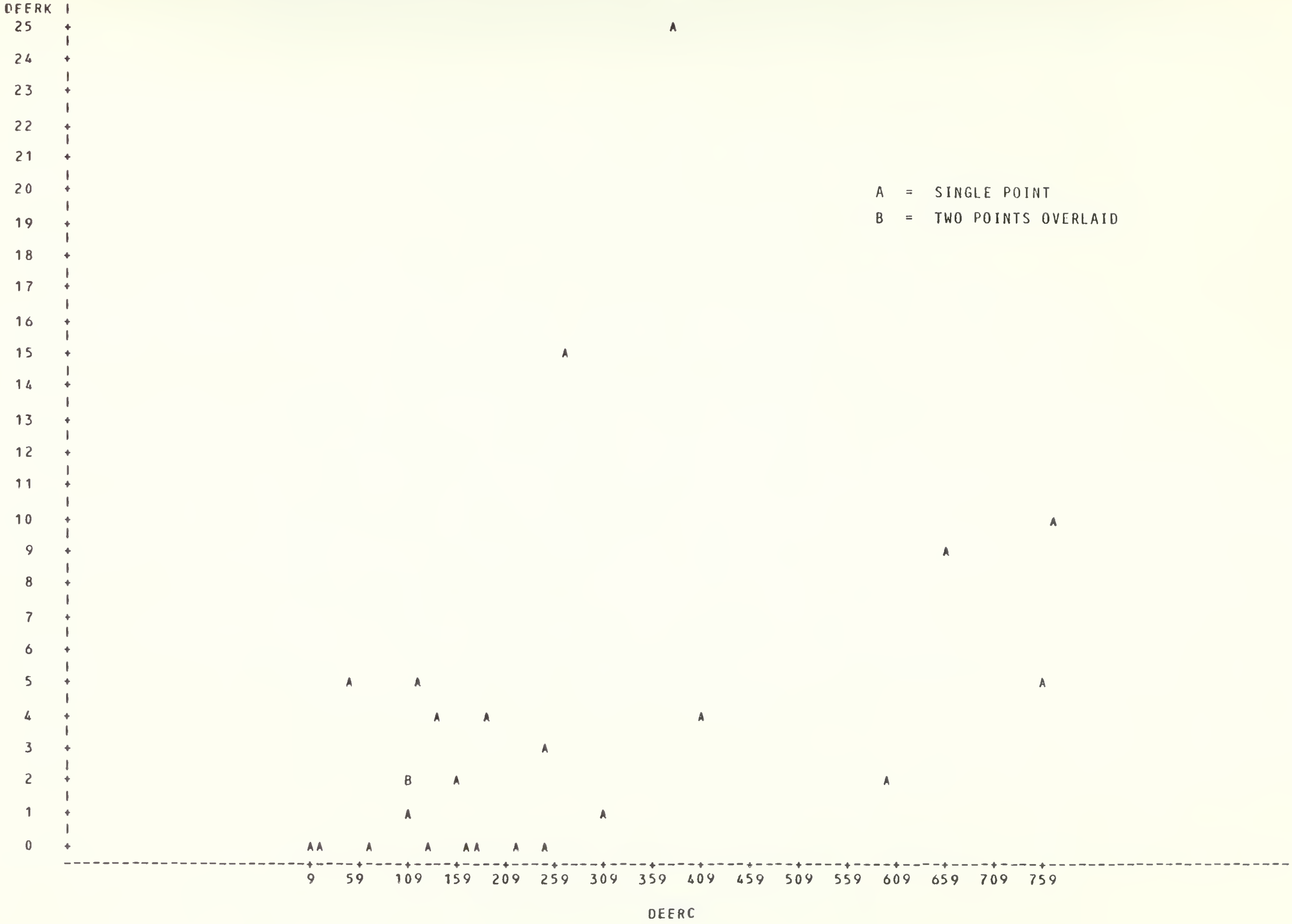

Figure A12.3.2-2 PLOT OF DEER KILL AND INCOMING CARS AT GUARD SHACK

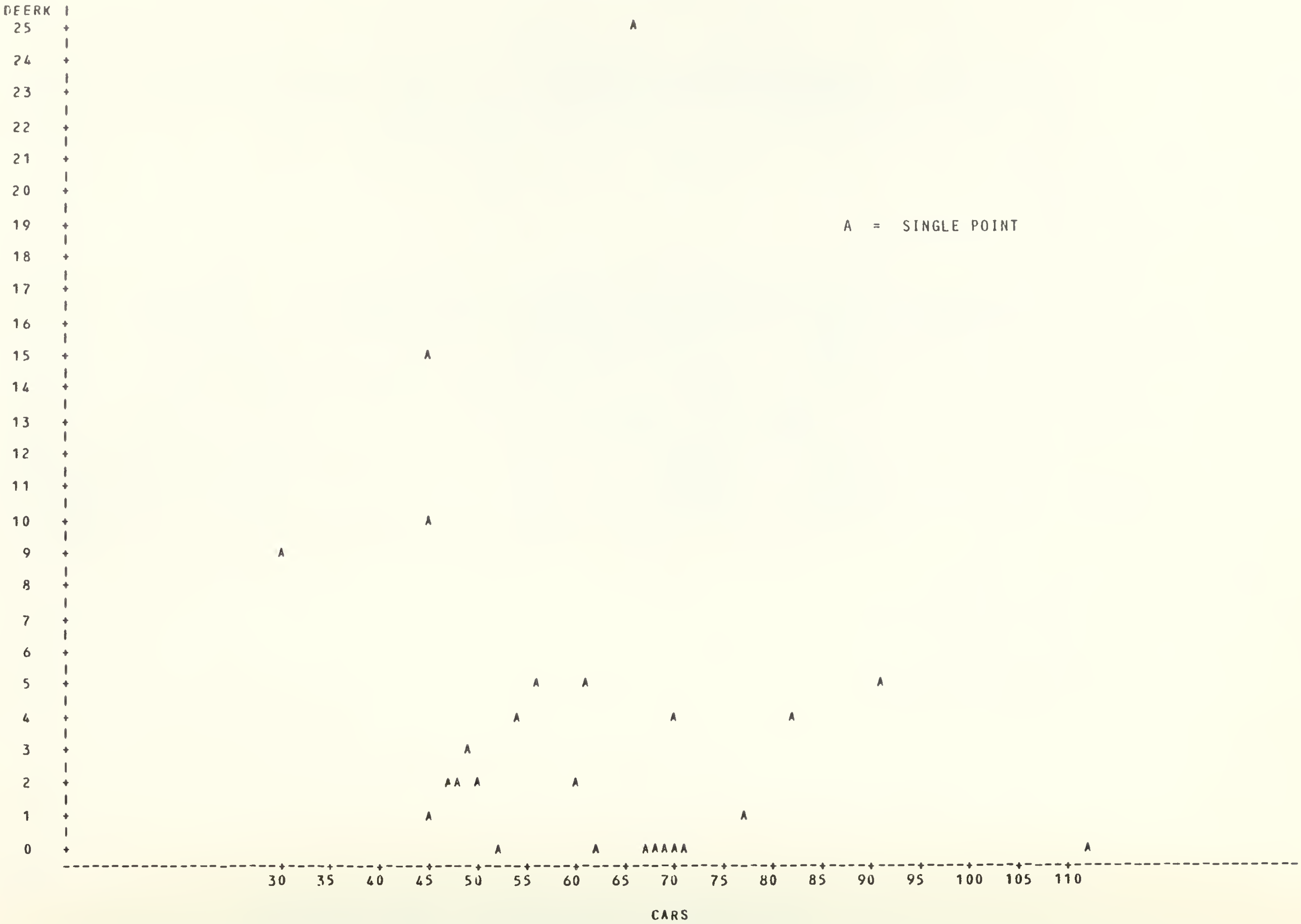

Figure A12.3.2-3 PLOT OF DEER KILL AND SNOW DEPTH

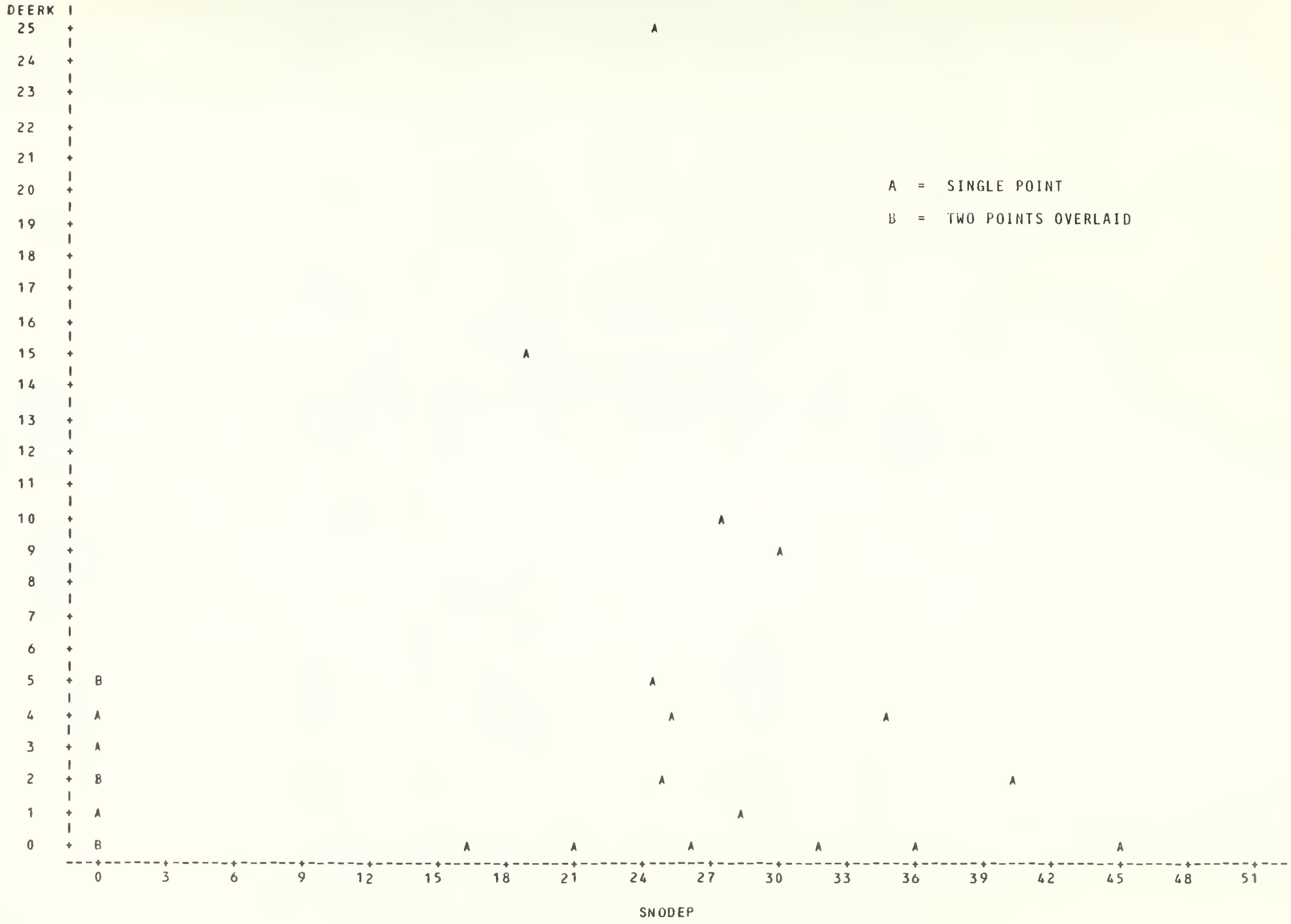

Figure A12.3.2-4 PLOT OF DEER KILL AND PRECIPITATION

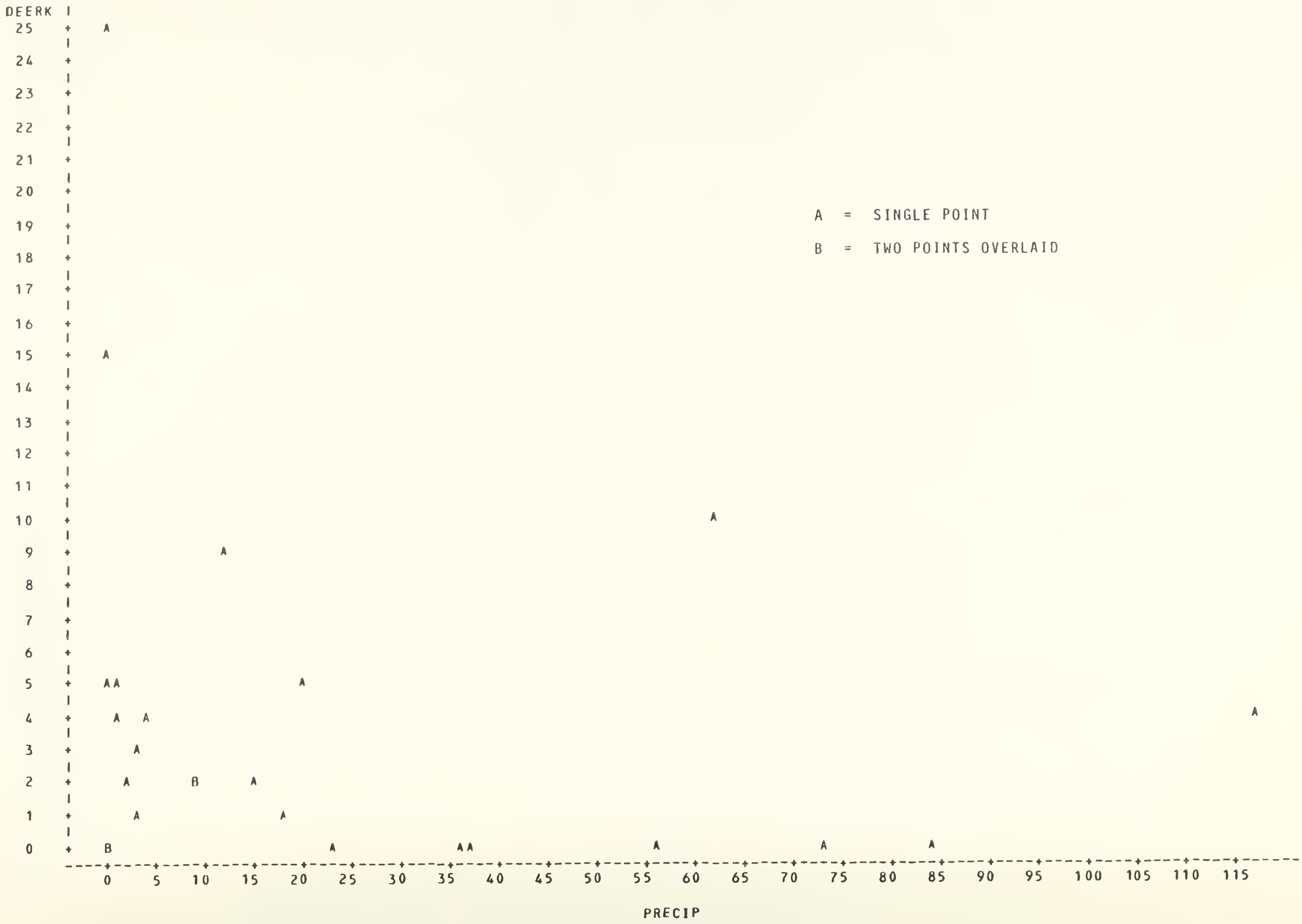

Table A12.3.2-1

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                 STEPWISE      REGRESSION ANALYSIS STATISTICS   -  STEP 1

 VARIABLE          MEAN        STANDARD        CORRELATION     REGRESSION      ST. ERROR,      COMPUTED
NO. NAME                       DEVIATION         X VS Y        COEFFICIENT     OF REG.COEF.    T VALUE
 3 OCT1       256.75977      221.43738         0.40638        0.00959         0.00602         1.59243
 5 CAR1        61.87999       17.23685        -0.22688       -0.01038         0.07677        -0.13516
 9 PREC        23.39999       31.52641        -0.20645       -0.02918         0.03604        -0.20956
DEPENDENT
 2 KILL         3.96000        5.73352


INTERCEPT                      2.82307

MULTIPLE CORRELATION           0.43667

STD. ERROR OF ESTIMATE         5.51412


                       ANALYSIS OF VARIANCE FOR THE REGRESSION

    SOURCE OF VARIATION           DEGREES        SUM OF           MEAN              F VALUE
                                 OF FREEDOM     SQUARES          SQUARES

ATTRIBUTABLE TO REGRESSION          3         150.44177         50.14725          1.64928
DEVIATION FROM REGRESSION          21         638.51709         30.40556
     TOTAL                         24         788.95874
```

Table A12.3.2-2

```
                 STEPWISE      REGRESSION ANALYSIS STATISTICS   -  STEP 2

 VARIABLE          MEAN        STANDARD        CORRELATION     REGRESSION      ST. ERROR,      COMPUTED
NO. NAME                       DEVIATION         X VS Y        COEFFICIENT     OF REG.COEF.    T VALUE
 3 OCT1       256.75977      221.43738         0.40638        0.01026         0.00592         1.73318
 5 CAR1        61.87999       17.23685        -0.22688       -0.00654         0.07602        -0.08608
DEPENDENT
 2 KILL         3.96000        5.73352


INTERCEPT                      1.73167

MULTIPLE CORRELATION           0.40673

STD. ERROR OF ESTIMATE         5.47077


                       ANALYSIS OF VARIANCE FOR THE REGRESSION

    SOURCE OF VARIATION           DEGREES        SUM OF           MEAN              F VALUE
                                 OF FREEDOM     SQUARES          SQUARES

ATTRIBUTABLE TO REGRESSION          2         130.51462         65.25731          2.18038
DEVIATION FROM REGRESSION          22         658.44434         29.92928
     TOTAL                         24         788.95874
```

Table A12.3.2-3

```
                 STEPWISE      REGRESSION ANALYSIS STATISTICS   -  STEP 3

 VARIABLE          MEAN        STANDARD        CORRELATION     REGRESSION      ST. ERROR,      COMPUTED
NO. NAME                       DEVIATION         X VS Y        COEFFICIENT     OF REG.COEF.    T VALUE
 3 OCT1       256.75977      221.43738         0.40638        0.01052         0.00493         2.13300
DEPENDENT
 2 KILL         3.96000        5.73352


INTERCEPT                      1.25834

MULTIPLE CORRELATION           0.40638

STD. ERROR OF ESTIMATE         5.35142


                       ANALYSIS OF VARIANCE FOR THE REGRESSION

    SOURCE OF VARIATION           DEGREES        SUM OF           MEAN              F VALUE
                                 OF FREEDOM     SQUARES          SQUARES

ATTRIBUTABLE TO REGRESSION          1         130.29294        130.29294          4.54971
DEVIATION FROM REGRESSION          23         658.66602         28.63765
     TOTAL                         24         788.95874
```

APPENDIX I

Socio - Economic Monitoring Reports 2, 3, & 4

C-b Shale Oil Venture

Socio-Economic Monitoring Report

Number Two
(Quarterly Report)
November 30, 1978

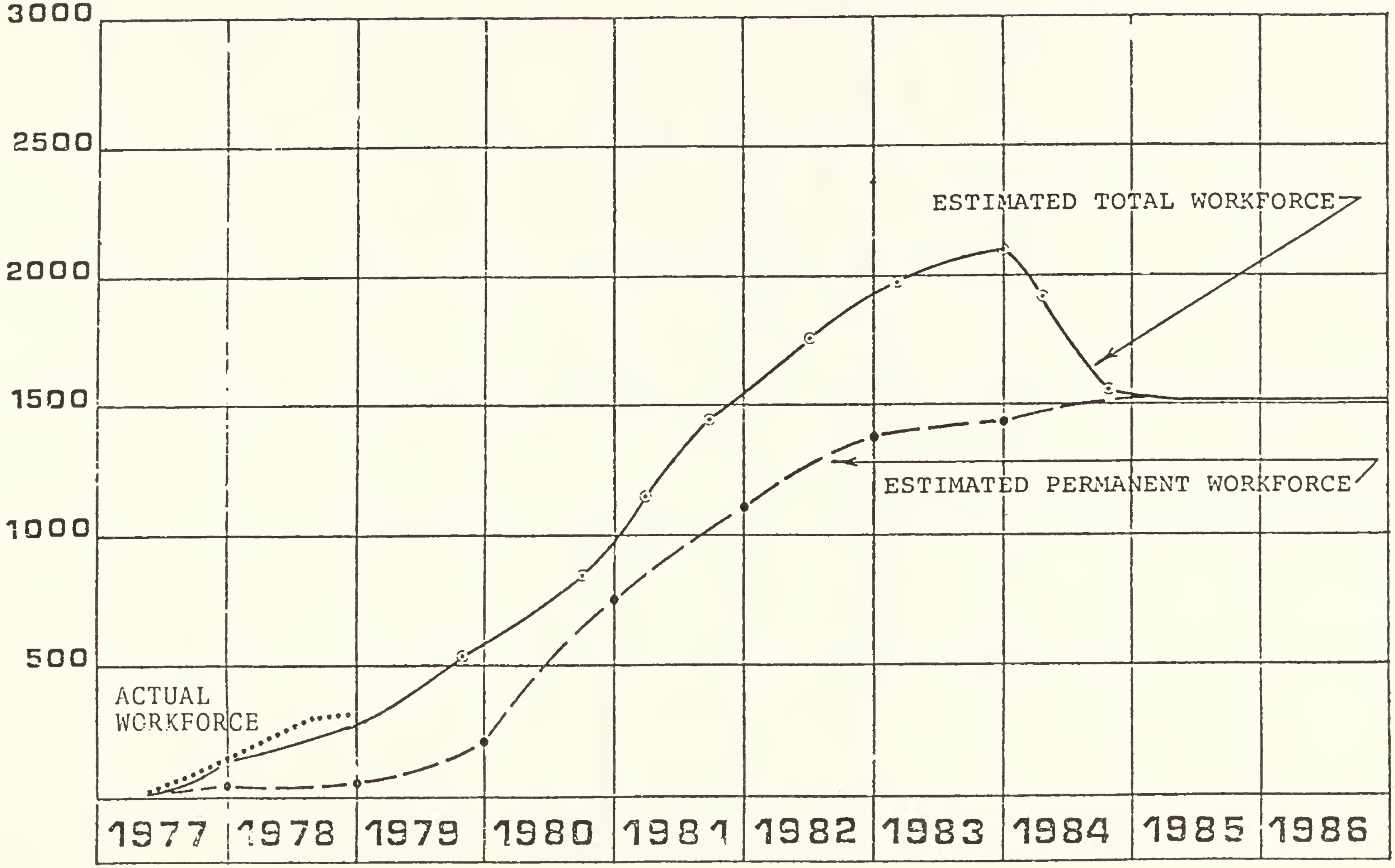
This is the second report which provides selected information on the C-b project workforce. The data for the report was collected through a questionnaire given to those employed at the C-b site. Completed surveys are available from 60% of the current workforce, therefore the statistics used in this report are estimates rather than actual numbers.

The C-b Workforce

The workforce reached a high in September of about 375. The workforce level at the end of November, 1978 was 282. The decrease of about 18 workers, since the July Monitoring Report, which indicated approximately 300 employees, is a temporary condition due to completion of the shaft headframes. The number of workers will increase again in January when shaft sinking resumes. About 90 percent of the workers still hold construction or temporary jobs at the site, while only 10 percent of the workers are considered permanent. Figure A shows the actual workforce as it compares to the projected workforce.

The majority (51.8%) of the worker's surveyed reside in Rifle. Table I shows the place of residence of the workers surveyed. A comparison of the place of residence of employees as shown in this report with that shown in the first monitoring report indicates that the percentage of employees living in Rifle and Silt has decreased whereas the percentage in Meeker has remained the same.

C-b Shale Oil Venture



OCCIDENTAL OIL SHALE PROCESS PROJECT MANPOWER ESTIMATE

FIGURE A

TABLE I

PLACE OF RESIDENCE

Community	Percent of C-b Work-force Residing there July, 1978 (N = 296)	Percent of Workers Surveyed, Residing there, Nov., 1978 (N = 168)
Rifle	54.7	51.8
Grand Junction Area	6.4	13.1
Meeker	7.1	7.1
Silt	10.1	5.4
Glenwood Springs	4.1	3.6
Rangely	.7	2.4
New Castle	4.7	2.4
Craig	-	1.8
Grand Valley	3.4	-
Piceance Creek	1.7	-
Denver Area	1.0	-
Other West Slope	5.1	2.4
Outside State	1.0	2.9
Unknown	-	7.1
	100.0%	100.0 %

Most of the workers are residing in these communities on a full time basis, while 15.5 percent indicated they live in a community close to the C-b site on weekdays and return to their permanent residence on weekends.

Approximately 62 percent of the workers responding have lived in their present home less than a year, while the other 38 percent have resided at their present location for over one year. Over half of the workers who live in Rifle, Meeker, and Glenwood are newcomers to those communities. Table II indicates the percentage of employees in each community according to the length of their residence.

TABLE II

LENGTH OF RESIDENCE

Community	Percent of C-b Workforce Residing there More than One Year	Percent of Workers Residing there less than One Year	
Rifle	21.8	78.2	100%
Grand Junction	68.2	31.8	100%
Meeker	33.3	66.6	100%
Silt	88.8	11.1	100%
Glenwood	50.0	50	100%
All Other Communities	46.9	53.1	100%

The median age of the employees is 28. About seventy percent of the workforce surveyed were married. For those employees living in Rifle and Meeker, the percentage married is greater than it is for the total workforce, but it should be noted that many of those employees have not brought their families with them. Table III indicates the percentage of workers, married and single, surveyed according to place of residence. The average family size for the married workers surveyed was 3.3, or an average of 1.3 children per family.

Of those employees living in Rifle less than a year, 40 percent have their families living with them. The new residents in Rifle have brought an average of 1.1 school children per family.

When asked to state if they were planning to move their families into the area, 20 of the workers showed they were planning to move their spouses to Rifle, bringing with them 21 school age children. Therefore, based on the return of the questionaire from 60% of the workforce, it is estimated that a total of 25 of the workers will move their spouse to Rifle with 28 school age children.

In Meeker, 85 percent of the employees responding to the survey living there less than a year, have their families living with them. These employees have brought four school age children to the community within the last year.

TABLE III
MARITAL STATUS OF WORKFORCE

Community	Percent Married	Percent Single	
Rifle	72.4	27.6	100%
Grand Junction Area	54.5	45.5	100%
Meeker	75	25	100%
Silt	66.6	33.3	100%
Total of Workers Surveyed	69.6	30.4	100%

Type of Residence of The Workforce

Table IV lists the percentages of the workforce in various types of residences. In Meeker, Grand Junction and Silt a greater percentage of residents are living in houses than in any other type of residence. In Rifle, the largest percentage of the workforce is living in apartments. When asked to state what type of residence the workers preferred, the majority indicated single family housing. Table V shows the preferences, in detail.

TABLE IV

TYPE OF RESIDENCE OF WORK FORCE

Type of Residence	% of Total Workforce	% of Residents Rifle	% of Residents Grand Junction	% of Residents Meeker	% of Residents Silt
Own House	23	18.4	29.4	33.3	22.2
Rent House	15.8	6.8	29.4	16.6	55.5
Own Mobile Home	14.5	14.9	17.6	8.3	11.1
Rent Mobile Home	10.3	10.3	5.8	16.6	11.1
Apartment	28.5	37.9	11.8	25	0
R.V./Camper	5.4	8	5.8	0	0
Motel	2.4	3.4	0	0	0
	100 %	100 %	100 %	100 %	100 %

TABLE V

HOUSING PREFERENCES OF THE WORKFORCE

Type	Percent Responding
House	60.4
Apartment	22.9
Mobile Home	16.6
	100 %

Monthly figures provided by local realtors in Rifle and Meeker give an indication of the housing availability and cost in the communities. Table VIII indicates the housing availability in Rifle. In Rifle, the median unit price increased 12% for new housing and 6% for old units during the three months from September to November. The median cost of residential lots for sale increased 33% from September to November.

TABLE VIII

RIFLE HOUSING AVAILABILITY REPORT

	September	October	November
No. New Units for sale	12	14	11
Median Unit Price	$59,000	$64,557	$66,180
Average weeks offered	6 weeks	7 weeks	5 weeks
No. Old Units for sale	24	28	23
Median Unit Price	$56,500	$57,100	$60,000
Average weeks offered	5 weeks	12 weeks	14 weeks
No. Resident Lots for sale	48	55	17
Median Lot Price	$12,200	$16,250	$16,250
No. Houses for Rent	None	None	None
No. Apartments for Rent	1	6	None
Median Rental	$ 425	$ 366	

Source: Leo Swartzendruber, Rifle Realty, Inc.

In Meeker, estimates of housing availability were provided by Bob Cox, Home Loan Officer at the First National Bank, who indicated that during the first half of November, average new homes were selling in the range of $47,500 to $52,000. Resident lots with water and sewer taps were selling in the range of $15,500 to

$17,500. Apartments for rent were very limited, with some two bedroom apartments renting for $350 to $400. There were no known mobile home spaces available.

Recreational Activities of the Workforce

When asked what type of recreational activities they participate in regularly, the employees indicated 72 different activities. Hunting, fishing and skiing were mentioned most frequently as recreational activities of both the employee and his or her family. Table IX shows the frequency of responses.

TABLE IX

RECREATIONAL ACTIVITIES

Activity	Percentage of Responses (N = 462)*
Hunting	22%
Fishing	22
Skiing	8
Camping	4
Bowling	3
Softball/Baseball	3
Swimming	3
Tennis	2
Basketball	2
Motorcycles/Dirtbikes	2
Horseback Riding	2
Drinking/Partying	2
All Others (Less than 2% Responding)	24

* Percent does not total 100% due to multiple response

The Typical C-b Employee

During the fall of 1978, the "typical" C-b employee was a 28 year old, married man. He lived in Rifle with his wife and child He is a new resident in the community and paid $360 per month for his apartment. When he was not working, he enjoyed hunting and fishing.

C-b SHALE OIL VENTURE

SOCIO-ECONOMIC MONITORING REPORT

NUMBER THREE
(ANNUAL REPORT)

February, 1979

Prepared by

Quality Development Associates, Inc.

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INTRODUCTION

This is the third monitoring report, issued by the C-b shale oil project. This report contains selected information on the C-b project workforce and socio-economic conditions within nearby communities. The workforce data presented in this report reflects current conditions, as of February, 1979. The community data is tabulated for the year, 1978, whenever possible and is analyzed in comparison with data from previous years.

The workforce data was collected through a questionnaire completed by persons employed at the C-b site. Completed surveys are available from 66 percent of the current workforce, therefore the statistics presented in this portion of the report are estimates rather than actual numbers.

The community data was collected from various sources in the communities of Rifle and Meeker; and from Garfield and Rio Blanco counties.

I. THE C-b WORKFORCE

The on-site workforce included a total of 253 persons as of February, 1979. This is a decrease of 29 workers since the last monitoring report was released in November, 1978. The activity lag between the completion of the head frame construction and resumption of shaft sinking accounts for the temporary decrease in the workforce. The workforce is anticipated to rise through 1979 to the level indicated in Figure A, as shaft sinking activity increases.

About 90 percent of the workers still hold construction or temporary jobs at the site, while 10 percent of the workers are considered permanent. Figure A shows the actual workforce as it compares to the projected workforce.

A. Housing

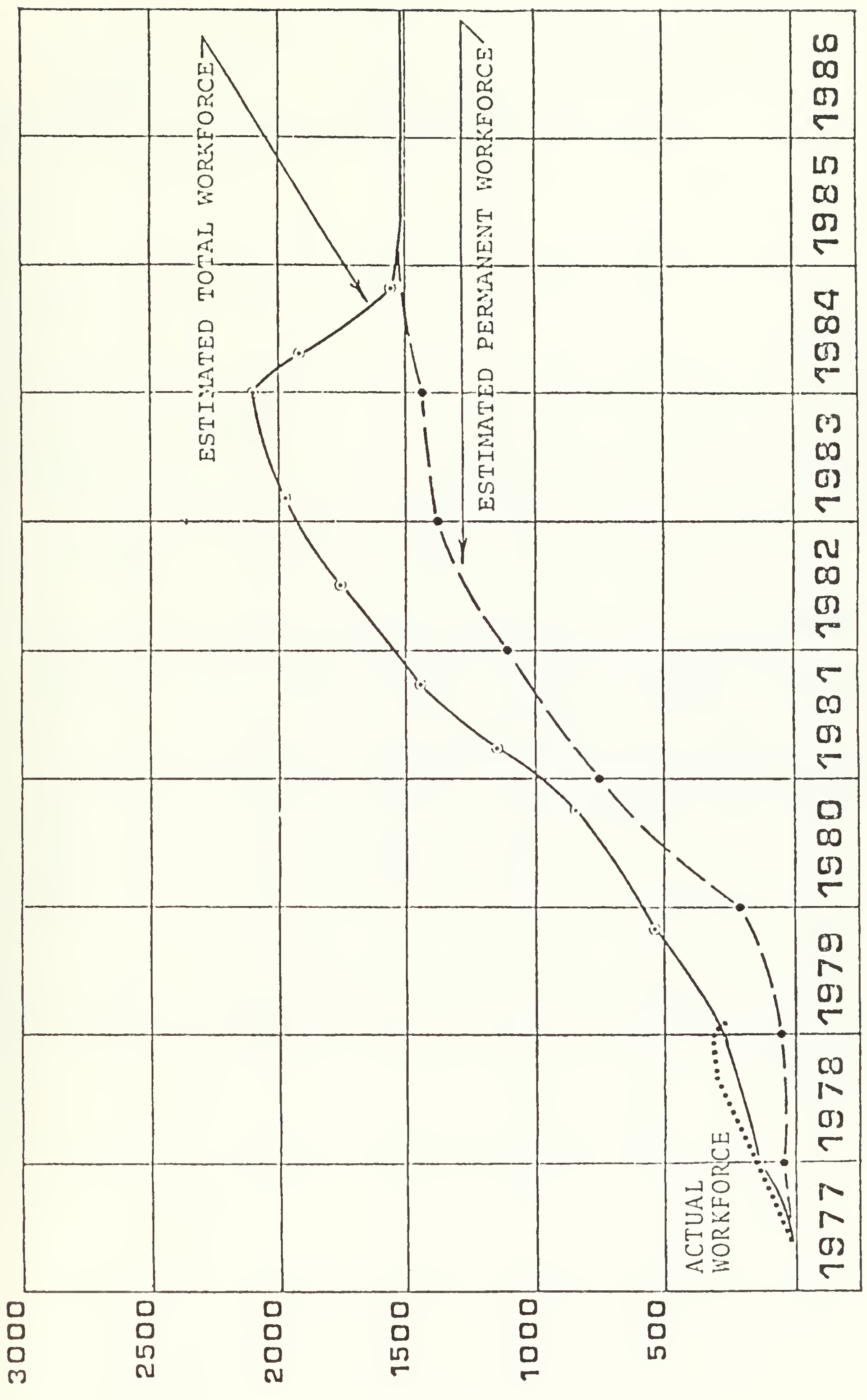
1. Location

The majority (56%) of the workers surveyed reside in Rifle. This percentage has remained relatively constant since July,1978. Table I shows the place of residence of all workers surveyed as of February, 1979 and compares those figures with the figures released in July, 1978.

2. Length of Residence

Approximately 60 percent of the workers surveyed have lived in their present homes less than a year, while 40 percent have resided at their present location for over one year. Seventy-two percent of the workers living in Rifle are newcomers to that community, while 58 percent of the workers living in Meeker have resided there less than one year. These figures seem to reflect the tendency for workers,who have recently

C-b Shale Oil Venture



OCCIDENTAL OIL SHALE PROCESS PROJECT MANPOWER ESTIMATE

FIGURE A

TABLE I

PLACE OF RESIDENCE

Community	Percentage of Workers Surveyed, Residing There February, 1979 (N = 168)	Percent of Workers Surveyed, Residing There July, 1978 (N = 296)
Rifle	56	55
Meeker	8	7
Silt	8	10
Grand Junction Area	7	6
Glenwood Springs	4	4
New Castle	3	5
Grand Valley	1	3
Rangely	0	1
Other West Slope	2	5
Piceance Creek	0	2
Denver Area	-	1
Outside Colorado	4	1
Unknowr	7	-
TOTAL	100	100

relocated to the project area, to establish residence in either Rifle or Meeker. Table II shows the percentage of employees in each community according to the length of their residence.

TABLE II

LENGTH OF RESIDENCE

Community	Percent of C-b Workforce Residing There More than One Year	Percent of C-b Workforce Residing There less Than One Year	
Rifle	28	72	100%
Meeker	42	58	100%
Silt	77	23	100%
Grand Junction Area	73	27	100%
Glenwood Springs	57	43	100%
All Other Communities	43	57	100%
Total Workforce	40	60	100%

3. Type

Table III lists by community the percentages of the workforce living in various types of housing. Approximately the same percentage of the total workforce own their own house, rent houses and/or rent apartments. Of the employees residing in Rifle, 50 percent live in a home which they own, while 23 percent of employees living in Meeker own homes.

TABLE III

TYPE OF RESIDENCE OF WORK FORCE

Community	Own House	Rent House	Own Mobile Home	Rent Mobile Home	Apartment	RV	Motel	
Rifle	34	12	16	7	24	4	3	100%
Meeker	23	46		8	23	-	-	100%
Silt	13	47	16	7	6	-	-	100%
Total Workforce	25	23	16	5	22	3	6	100%

4. Preference

When asked to state what type of residence they preferred to be living in, the majority of workers indicated single family housing. Table IV shows the preferences in detail.

TABLE IV

HOUSING PREFERENCES OF THE TOTAL WORKFORCE

Preferred Type	Percent Responding
Single Family House	76
Mobile Home	13
Apartment	11

5. Cost

Response to the survey showed the median cost of housing per month to be $248 for home owners, $200 for home renters, $200 for mobile home owners, $155 for mobile home renters, and $225 for apartment renters. (See Table V). However, these figures are lower than the data on current housing and rental costs in the local communities presented in the Housing and Land Use Section of this report. The median monthly cost of housing to the workforce is low, since it includes cost for long term residents, who gnerally pay less for housing and single status workers, who live together and share costs. The low and high figure in Table V reflects the large range in monthly cost of housing to the C-b workforce.

TABLE V

MONTHLY COST OF HOUSING TO THE C-b WORKFORCE

Type	Median	Low Figure	High Figure
Own House	$248	$ 50	$700
Rent House	$200	$ 60	$450
Own Mobile Home	$200	$ 60	$440
Rent Mobile Home	$155	$ 50	$300
Apartment	$225	$100	$350

B. Age, Marital Status and Family Size

1. Age

The median age of current employees is 31 years. This is three years older than that recorded in the last report.

2. Marital Status

About 70 percent of the workers surveyed are married, but only 46 percent are living with their families full-time. Table VI shows the percentage of workers, by community; who are married and reside with their families; who are married but do not reside with their families full-time; and who are single.

3. Family Size

Average family size for all married members of the workforce is 3.5 persons, or two adults and 1.5 children per family. An estimated 60 C-b worker families

TABLE VI

MARITAL STATUS OF WORKFORCE

Community	Percent Married and Living With Family	Percent Married But Not Living With Family Full-time	Percent Single	
Rifle	49	26	25	100%
Meeker	58	17	25	100%
Silt	61	8	31	100%
Grand Junction Area	36	9	55	100%
Glenwood Springs	43	14	43	100%
All Others	31	34	35	100%
Total Workforce	46	24	30	100%

have relocated to communities close to the project within the past year. These families have contributed approximately 100 children to the area, of which an estimated 55 are school-age children (ages 5-18).

In Rifle, an estimated 42 families of C-b workers are new to the community, and they have contributed approximately 70 children of which about 40 are school age.

About 30 of the present C-b workers who have families, but who do not have their families in the local area, are planning to have their families join them in the near future. Most of these new families are planning to settle in Rifle and would contribute an estimated 25 new school children to that community.

C. Recreational Activities

The most popular recreation activities among the C-b workerforce are fishing, hunting and skiing. Fishing, hunting and swimming appear to be the most popular activities among family members of C-b workers.

Table VII lists the percentages of the workers and the percentages of worker family members who participate in various recreational activities.

TABLE VII

RECREATIONAL ACTIVITIES

Activity	Percentage of the Workforce Participating*	Percentage of Worker Family Members Participating*
Fishing	30	26
Hunting	29	19
Skiing	19	9
Camping	10	7
Basketball	7	1
Swimming	6	11
Tennis	6	5
Bowling	4	
Golf	3	
Horseback Riding	3	1
Four-Wheeling	3	
Softball/baseball	2	
Motorcycling	2	1
Waterskiing	2	

* Does not total 100 percent due to multiple responses.

Other responses include: dancing, football, photography, macrame, flying, tubing, trapping, horseshoes, running, movies, gardening.

II. THE COMMUNITIES

A. Housing and Land Use

1. Rifle

The community of Rifle continues to show the most growth in housing and subdivision development. According to the Rifle Building Department, 257 building permits were issued in 1978. This number is more than double the number of permits issued in 1977. In Rifle there were seventy new homes built in 1978; four town houses, thirteen four-plexes including the senior citizen housing project, twelve duplexes, and six new commerical buildings. The valuation of the new construction was $5,556,668 in 1978, while in 1977 the valuation was $2,606,000. In 1978 a total of sixty-one mobile home permits were also issued in Rifle.

During the fourth quarter in 1978 the average sales price of a new single family home in Rifle was $55,241. This is 19 percent higher than the average price of a home during the fourth quarter in 1977 (see Table VIII.) The average sales price for existing housing during the fourth quarter 1978 was $60,872, forty-four percent higher than in 1977. The average residential lot price, in the fourth quarter, increased 70 percent in 1978 from $9,921 in 1977 to $16,878 in 1978.

Cost of rental housing has also increased in Rifle. Although there were no houses available for rent in the fourth quarter of 1978, the first monitoring report, released in July, showed that the average rent for single family housing was $200. The most dramatic increase in rents were for apartments. The average rental price for an apartment rented during the fourth quarter 1978 was $355, a 140 percent increase over the average rental of $148 in 1977.

TABLE VIII

AVERAGE HOUSING AND RENTAL COSTS IN RIFLE FOR FOURTH QUARTER 1976-1978

	Oct-Dec 1976	Oct-Dec 1977	Oct-Dec 1978	Percent Increase 1977-1978
Average sales price for new houses	$41,937	$46,392	$55,392	19%
Average sales price for existing houses	$39,411	$42,228	$60,872	44%
Average resident lot price	$ 6,840	$ 9,921	$16,878	70%
Average advertised monthly rental for houses	$ 148	$ 188	None Available	
Average advertised monthly rental for apartments	$ 139	$ 148	$ 355	140%

Source: Lynn Behrns, former Rifle Planner
Leo Swartzendruber, Rifle Realty

2. Meeker

Meeker also continues to grow, although it shows less growth than Rifle. According to county warranty deeds, which give information on housing sales and prices, the average sales price of a home in Meeker increased from $46,237 in the first half of 1978 to $48,083 in the second half. The greatest number of homes sold were in the $50,000 to $54,999 range. The total number of houses sold in Meeker is estimated to be 60 homes in 1978 (see Table IX.)

A telephone survey in January, 1979 of three major rental property owners in Meeker, indicated only one house and four apartments advertised for rent. Recently constructed apartments in Meeker rented between $275 and $350 per month in July, but in January 1979 were renting between $355 to $400. Depending on the renter, the owner of the property, and the type of rental property, rents may vary in Meeker anywhere from $150 to $400 per month.

TABLE IX

HOUSING SALES AND PRICE RANGES IN MEEKER
1978

	January-June	July-December	Total
Sales	30	18	48
Price Volume	$1,387,100	$ 865,500	$2,252,600
Avarage Price	$ 46,237	$ 48,083	$ 46,929
Sales by Price Range			
$25-29,999	3	0	3
30-34,999	5	0	5
35-39,999	3	4	7
40-44,999	3	2	5
45-49,999	5	2	7
50-54,999	5	5	10
55-59,999	3	3	6
60-64,999	0	2	2
65-69,999	0	0	0
70-74,999	2	0	2
75-79,999	0	0	-
80,000 +	1	0	1

Source: Survey of Warranty Deeds, Clerk's office, Rio Blanco County and Credit Bureau Bulletin, Craig Credit Collection Service and QDA, A Housing Market Feasibility Analysis, 1979, Rio Blanco County.

Those housing sales where there was no land transaction (new construction on previously purchased subdivision lot) are not accounted for in Warranty Deeds. It is estimated that this later group of sales is approximately 20% of all sales in Meeker. Therefore, total sales in Meeker is estimated to be 58 homes.

B. Law Enforcement

1. Rifle

Growth has affected the number of crimes reported to the police in both Rifle and Meeker. The total number of crimes reported increased 86 percent from 1977 to 1978 in Rifle. Increases in criminal activity in Rifle were primarily in the categories of theft, drugs, disorderly conduct, criminal trespass, criminal mischief, child abuse and neglect, runaway and curfew violations. Traffic accidents increased 71 percent (see Table X.).

TABLE X

RIFLE LAW ENFORCEMENT DATA 1976-1978

Selected Crimes Reported [1]	1976	1977	1978	1977-78 Percent Increase
Theft	85	119	182	53
Narcotics/Drugs	7	5	15	200
DUI/DWI [2]	32	27	74	174
Disorderly Conduct	18	15	70	366
Criminal Trespass	11	17	26	53
Criminal Mischief	37	28	48	71
Family Disturbance	3	6	2	(- 66)
Child Abuse/Neglect		7	9	29
Runaways	16	9	18	100
Curfew Violation	9	8	14	75
Total Reports	395	371	690	86
Total Arrests	162	164	399	143
Total Juvenile Cases	95	95	160	68
Total Traffic Accidents		123	210	71

1. All crimes reported are not included in this report
2. Driving under the influence, driving while intoxicated.

Source: Rifle Police Department

2. Meeker

Crimes reported in Meeker increased 84 percent from 1977 to 1978. In Meeker, increases in crimes reported were primarily in the categories of assault, burglary, theft, sex offenses, disorderly conduct and fraud (see Table XI.).

TABLE XI

MEEKER LAW ENFORCEMENT DATA 1976-1978

Selected Crimes Reported [1]	1976	1977	1978	Percent Increase 1977-1978
Assault	6	8	11	38
Burglary	14	7	13	86
Theft	50	42	84	100
Sex Offenses	1	3	6	100
Narcotics	5	10	5	-50
Driving Under the Influence	13	24	24	0
Disorderly Conduct	6	8	25	88
Fraud	0	3	7	133
Runaway	7	11	11	0
Total Reports	123	174	320	84

1. All crimes reported are not included in this report

Source: Meeker Police Department

C. Schools

1. Rifle

Enrollment in Garfield School District RE-2 has decreased slightly according to figures representing Fall enrollment 1978 through February enrollment 1979. Dariel Clarke, the district superintendent, felt the decrease was temporary due to a decrease of construction workers during the winter months. Yet, current enrollment still shows an increase over the enrollment at the close of the Spring Term 1978. The RE-2 School District currently has the full time equivalent (FTE) of 94 certificated staff and 64 support staff employed. The assessed valuation of the school district increased 12 percent from 1977 to 1978, while the mill levy decreased (see Table XII.)

TABLE XII

GARFIELD SCHOOL DISTRICT RE-2 DATA

Enrollment	Spring 1977	Sept 1978	Oct. 1978	Nov. 1978	Dec. 1978	Jan. 1979	Feb. 1979
Elementary	887	922	913	938	932	922	917
Secondary	993	814	819	819	816	802	804
Total	1622	1740	1732	1732	1748	1724	1721

	1977	1978	1979
Staff			
Certificated (FTE)			94
Support Staff (Number employed)			64
Assessed Valuation	$18,554,630	$18,851,520	$21,167,920
Mill Levy	56.14	56.13	49.81

Source: Garfield School District RE-2 Superintendent

2. Meeker

The Meeker School District also showed a slight decrease in enrollment from Fall 1978 to January 1979. The school superintendent's office explained the decrease is due to workers who left the community upon completion of the Irbe construction project. Currently there are 46.35 (FTE) certified staff and 29 support staff. The assessed valuation has increased as well as the mill levy (see Table XIII) from 1978 to 1979.

TABLE XIII

MEEKER SCHOOL DISTRICT RE-1

Enrollment	Capacity	Spring 1978	Fall 1978	January 1979
Rock School (Grades 1-8)	40		21	27
Grades 1-4	350	352 (Total elementary)	276	257
Grades 5-6	150		126	124
Grades 7-8	250	113	118	106
Senior High	450	227	248	240
Total	1240	692	768	754
Staff				
Certified (FTE)				
Support (Number employed)				
Assessed Valuation		23,686,620	23,291,360	23,358,870
Mill Levy		40.67	43.67	48.05

Source: Meeker School District RE-1 Superintendent

TABLE XIV

SECONDARY DROPOUT RATES

School	1975-76	1976-77	1977-78
Rifle Senior High	11.4	5.7	18.0
Meeker Senior High	5.6	6.3	0
State High School Totals	7.8	9.3	9.8

Source: Colorado Department of Education

3. Secondary Drop-Out Rate

Secondary school drop-out rates are computed each year as a percent of October school enrollments for grades 10-12. The dropout rate increased during the 1977-78 school year in Rifle. The Meeker dropout rate decreased to zero (see Table XIV.)

D. Hospitals and Health Care

The Clagett Memorial Hospital in Rifle is still experiencing operating deficits due to its low level of occupancy. The administration is encouraged though, by a higher daily census recently. A hospital planning committee has been meeting on a monthly basis since last fall. One of their top priorities has been the recruitment of an additional physician to town, but that has not been achieved to date and the community continues to be served by four physicians.

The following is a breakdown of pertinent statistics for the hospitals in Meeker and Rifle. Statistics which reflect the full year 1978 are listed first. These are followed, for comparison, by numbers which reflect the first half of 1978 and which were published in the first monitoring report..

TABLE XV

HOSPITAL STATISTICS IN RIFLE AND MEEKER

	Clagett Memorial Hospital		Pioneer Memorial Hospital	
	1978	First Half 1978	1978	First Half 1978
Total Admissions	909	491	415	210
Total Emergency Room Visits	2356	1232	1354	526
Average Daily Census	8.3	8.1	5.8	6.7
Average Occupancy	26.0	25.3	34.4	39.7
Total Newborn	64	34	44	18

Source: Harald Frieser, Clagett Russ McDaniels, Pioneer

The statistics show that hospital functions have remained relatively stable in most areas throughout the year. In Meeker, there has been a noticeable increase in emergency room visits, but the daily census and average occupancy levels have declined since the first part of the year.

Economic Indicators

Included in this section are statistics which give some indication of economic trends within the communities of Meeker and Rifle (see Table XVI.)

TABLE XVI
ECONOMIC INDICATORS IN RIFLE AND MEEKER

	Meeker	Rifle
Municipal Budget		
1979 (Estimated)	$ 2,572,225	$ 1,107,700
1978 (Actual)	$ 1,550,210	$ 842,890
Municipal Debt		
December 1978	$ 2,240,000	$ 1,416,201
July 1978	$ 1,800,000	$ 614,000
Assessed Valuation		
December 1978	$ 5,225,880	$ 5,699,180
December 1977	$ 4,850,000	$ 4,984,000
Commercial Bank Total Deposits		
December 1978	$15,870,744	$17,056,000
December 1977	$14,512,000	$14,142,000
Commecial Bank Total Loans		
December 1978	$12,071,222	$11,697,000
December 1977	$ 9,746,000	$ 9,201,000
Retail Sales*		
1978 (Estimated)	$ 9,600,000	$19,991,000
1977	$ 8,186,601	$15,419,000

* Estimated based upon actual figures for January - September 1978. Fourth quarter 1978 figures are not yet available.

These figures are evidence of a growing economy in both Meeker and Rifle. Meeker's assessed valuation, a sign of real property growth, has increased by almost 8 percent over the year. Commercial bank deposits, an indicator of a growing money supply, have increased by 9 percent, while bank loans have increased by 24 percent. Retail sales in Meeker, the best indicator of commercial activity, increased 17 percent over the year. The demand upon public services and facilities in Meeker has shown a large increase, as the municipal budget has increased by 66 percent and the municipal debt by -25 percent.

In Rifle, the assessed valuation has increased by 14 percent in the last year. Commercial bank deposits jumped 21 percent and bank loans were up 27 percent. Retail sales in Rifle increased 30 percent over the year. Rifle also shows evidence of the pressure to expand public services in that the municipal budget increased 31 percent and the municipal outstanding debt level rose 130 percent over the year.

C-b SHALE OIL VENTURE

SOCIO-ECONOMIC MONITORING REPORT

NUMBER FOUR

(QUARTERLY REPORT)

APRIL, 1979

Prepared by

Quality Development Associates, Inc.

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INTRODUCTION

This is the fourth monitoring report, issued by the C-b Shale Oil Venture. This report contains selected information on the C-b project workforce. The data was collected through a questionnaire completed by persons employed on the C-b tract, and reflects the current workforce as of April 6, 1979. Sixty two percent of the workforce were surveyed, therefore the statistics presented in this report are estimates rather than actual numbers.

I. THE C-b WORKFORCE

As of April 6, 1979 there were 245 persons employed at the C-b site. This is a slight decrease from the 253 persons employed as of February 1979.

About 90 percent of the workers still hold construction or temporary jobs at the site, while 10 percent of the workers are considered permanent. Figure A shows the actual workforce as it compares to the projected workforce.

A. Housing

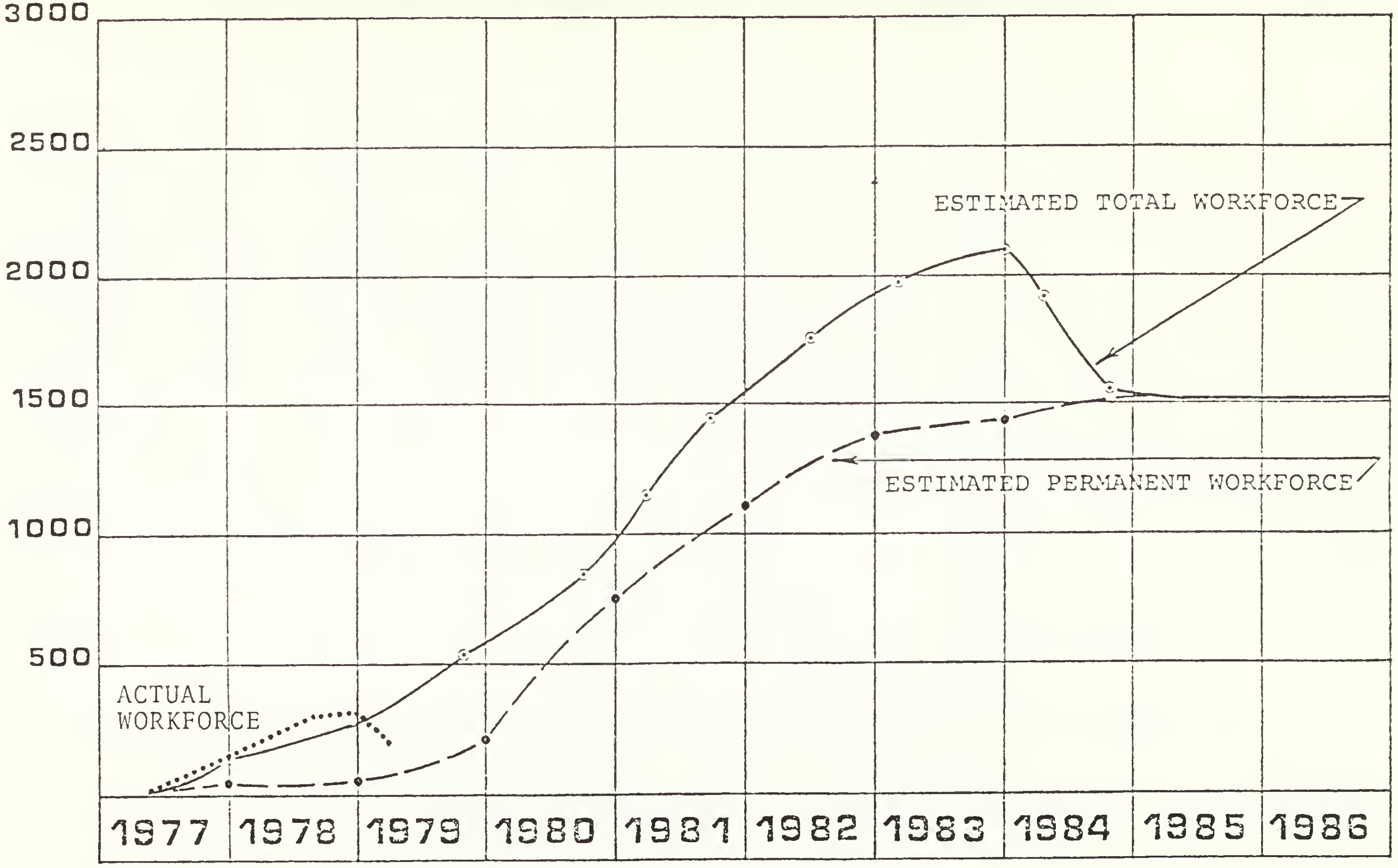
1. Location

Most of the workers (52%) reside in Rifle, although there has been a slight percentage decrease from the previous monitoring reports. An increased percentage of workers are residing in Meeker. Table I shows the place of residence of all workers surveyed as of April 6, 1979 and compares those figures with those released in February 1979.

2. Length of Residence

The percentage of workers who have lived in their present homes less than a year has remained at 60 percent, while 40 percent have resided at their present location over a year. The percentage of workers who are newcomers to Rifle has remained relatively constant, around 70 percent, while in Meeker, the percentage of workers who lived there less than a year increased from 58 percent in February to 81 percent in April 1979. Table II shows the percentage of employees in each community according to the length of their residence.

C.b Shale Oil Venture



OCCIDENTAL OIL SHALE PROCESS PROJECT MANPOWER ESTIMATE

FIGURE A

TABLE I

PLACE OF RESIDENCE

	Percentage of Workers Surveyed Residing There April 1979 (N=153)	Percentage of Workers Surveyed Residing There February 1979 (N=168)	Percentage of Workers Surveyed Residing There July 1978 (N=296)
Rifle	52	56	55
Meeker	10	8	7
Silt	8	8	10
Grand Junction Area	6	7	6
Glenwood Springs	5	4	4
New Castle	4	3	5
Grand Valley	2	1	3
Rangely	1	0	1
Other West Slope	1	2	5
Piceance Creek		0	2
Other Colorado	1	0	1
Outside Colorado	2	4	1
Unknown	8	7	0
Total	100	100	100

TABLE II

LENGTH OF RESIDENCE
(April 1979)

Community	Percent of Workers Surveyed Residing there more than one year	Percent of Workers Surveyed Residing there less than one year
Rifle	30	70
Meeker	19	81
Silt	83	17
Grand Junction Area	77	23
Glenwood Springs	100	0
All other Communities	33	67
Total Workforce	40	60

Of those workers listing their permanent residence as out of state, the majority are from Utah, while others list the States of Washington, Nevada, Arizona, New Mexico, South Dakota, Minnesota, California, West Virginia, Michigan, Oregon and Mississippi, as home.

3. Type

Table III presents the various types of housing in which the workers are living. A comparison of the current statistics with the February, 1979 monitoring report shows that a slightly greater percentage of the total workforce own their own houses and rent apartments.

TABLE III

PERCENT OF WORKFORCE RESIDING IN VARIOUS TYPES OF HOUSING April 1979

Community	Own Home	Rent Home	Own Mobile Home	Rent Mobile Home	Apartment	RV	Motel	
Rifle	25	13	18	5	33	3	3	100%
Meeker	19	19	19	0	43	0	0	100%
Silt	25	41	17	17	0	0	0	100%
Total Workforce	27	18	16	6	29	1	3	100%

4. Preference

The majority of the workers indicated they preferred to live in single family housing. Table IV shows the preferences of the current workforce are similar to the previous monitoring report.

TABLE IV

HOUSING PREFERENCES OF THE TOTAL WORKFORCE

Preferred Type	% Responding February 1979	% Responding April 1979
Single Family House	76	73
Mobile Home	13	14
Apartment	11	13

5. Cost

Response to the survey showed the median monthly cost for home owners to be $248, $200 for home renters, $165 for mobile home owners, $100 for mobile home renters and $240 for apartment renters.

Table V shows how the current median cost compares with the figures presented in the last monitoring report.

TABLE V

MONTHLY COST OF HOUSING TO THE C-b WORKFORCE

Type	Median Cost Feb. 1979	Median Cost April 1979	Low Figure April 1979	High Figure April 1979
Own House	$248	$248	$103	$700
Rent House	200	200	150	400
Own Mobile Home	200	165	60	600
Rent Mobile Home	155	100	50	300
Apartment	225	240	100	350

Monthly figures provided by a Rifle realtor give an indication of housing cost in Rifle. Table VI shows the average cost for various types of housing in Rifle. For each type of housing except for apartment rentals, the average cost appears to be increasing.

TABLE VI

AVERAGE HOUSING AND RENTAL COSTS IN RIFLE

	Oct.-Dec. 1978	Jan.-March Average 1979
Average Sales Price for new houses	$55,392	$77,500
Average sales price for existing houses	$60,872	$63,250
Average resident lot price	$16,878	$17,662
average advertised monthly rent for houses	None available	None available
Average advertised monthly rent for apartments	$ 355	$ 325

Source: Leo Swartzendruber, Rifle Realty

B. Age, Sex, Marital Status and Family Size

1. Age

The Median Age of the employees has remained at 31 years.

2. Sex

Ninety-one percent of the current workforce are males, 9 percent are female.

3. Marital Status

Sixty-eight percent of the workforce are married, but only 49 percent live with their families full-time. Table VI shows the percentage of workers, by community, who are married and reside with their families; who are married but do not reside with their families full-time; and who are single.

TABLE VII

MARITAL STATUS OF WORKFORCE
April 1979

Community	Percent Married and living with Family	Percent Married But not living with Family Full-time	Percent Single
Rifle	46	22	32
Meeker	69	12	19
Silt	50	8	42
Grand Junction Area	56	22	22
Glenwood Springs	50	0	50
All Others	46	22	32
Total Workforce	49	18	33

4. Family Size

Average family size for all married members of the workforce is 3.3 persons or two adults and 1.3 children per family. Average family size for the total workforce (including singles) is 2.7 persons. It is estimated that 39 percent of the children are non-school age, while 61 percent are school-age children.

It is estimated that 41 of the workers have moved their families with them within the last year, to an area near the tract. They have brought with them an estimated 23 non-school age children and 40 school-age children.

About 14 of the present C-b workers, who are not living with their families, are planning to have their families join them in the near future. Most of these workers are planning to settle in Rifle and would contribute an estimated 30 new school children to that community.

C. Recreational Activities

Fishing, hunting, skiing and camping are still the most popular recreational activities of the workforce and their families. Other activities that were mentioned were basketball, swimming, tennis, bowling, golf, horseback riding, four-wheeling, softball, motorcycling, water skiing, flying, snowmobiling, biking, running, boating, raquetball and pistol shooting.

II. CORRECTIONS

Since the last monitoring report, it was learned that there were some figures that were incorrectly reported. Please make a note of these changes in your copy of the February 1979 Monitoring Report.

The enrollment figures for the Meeker School District did not include kindergarten. The revised numbers are:

MEEKER SCHOOL DISTRICT RE-1

January 1979

Enrollment	January 1979
Rock School (Grades 1-8)	27
Kindergarten	56
Grades 1-4	257
Grades 5-6	124
Grades 7-8	106
Senior High	240
Total	810

The number of certified (FTE) staff in Meeker in January, 1979 was 46 and the number of support staff was 29.

The February monitoring report showed the Rifle secondary dropouts rate for 1977-78 to be 18.0. This rate is actually only 7.7.

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Form 1279–3
(June 1984)

BORROWER'S

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